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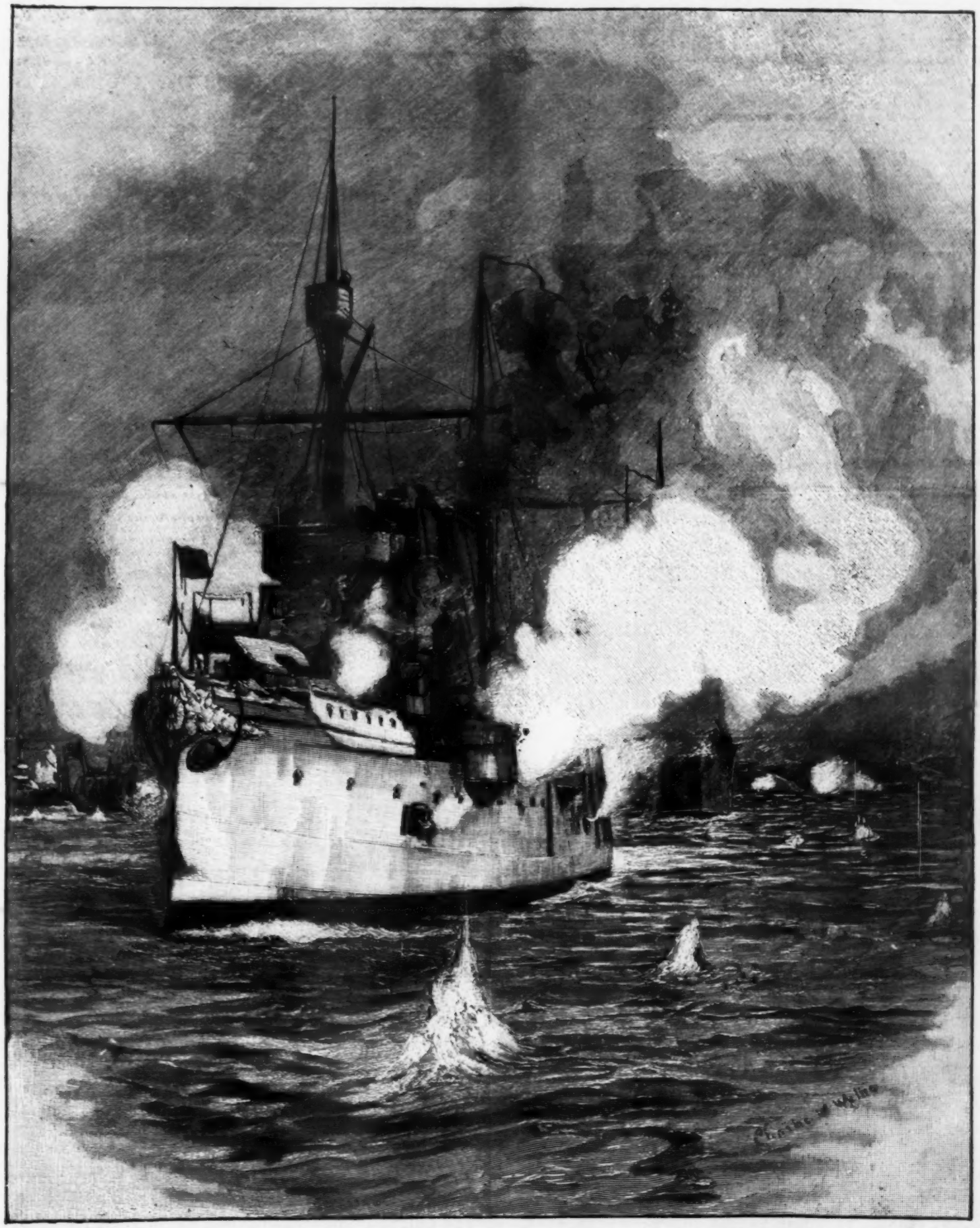


THE JAPANESE WAR SHIP YOSHINO, ENGAGED IN THE BATTLE OF YALU.

[From the Illustrated London News.]

[From the Engineer, London.]

THE NAVAL BATTLE OF YALU.

The various reports concerning the great naval battle of Yalu are so conflicting in many respects that it is difficult to write on the subject with desirable certainty. The very spelling of the names of the vessels engaged is perplexing. Under the circumstances we can scarcely hope to avoid falling into some error. But there are certain facts which are well known and beyond dispute, and these we propose to put before our readers here. In another page we have dealt as far as possible with the question of gun fire and its effects as displayed at Yalu.

We have engraved this week some of the most important of the Chinese war vessels which took part in the recent naval engagement at Yalu in Corea—the King Yuen and Lai Yuen, and the Chih Yuen and Ching Yuen—two pairs of sister vessels. The engravings are from photographs by Messrs. Symonds, of Portsmouth.

In September of 1887, a little squadron, consisting of two small battle ships and two moderate sized cruisers, accompanied by a sea-going torpedo boat of the first class, built by Yarrow, assembled at Spithead under command of Admiral Lang, they being destined for the re-enforcement of the Chinese imperial fleet. These vessels were identical with the four which we have illustrated to-day, and one out of each pair has gone down under the fire of the Japanese guns, the remaining vessels being hulled many times and pierced upon the water line, demonstrating the important part which the whole of them took in the engagement.

The King Yuen—sunk at Yalu—and the Lai Yuen, two small twin-screw barbette ships, partially armor belted and intended for coast defense, but capable of making extended passages at sea, were laid down for the Chinese government by the Vulcan Company at Stettin, and were launched, the first on January 3, 1887, and the last on March 25, 1887. They were completed in the summer of 1887, and left England, as mentioned above, in September of the same year.

The armor was compound, and consisted of a belt for protection of the engine and boiler rooms from 2 feet above the water line to 4 feet below it, and was 9½ inches to 5¼ inches thick. This belt was terminated and re-enforced by transverse bulkheads 8 inches thick. A protective deck 1½ inches thick extended over the belt, the extremities of the vessel being protected by an armored deck, sloping down, of 3 inches in thickness. Their heaviest guns were coupled in a pear-shaped redoubt forward of the funnels, with 8 inches of compound armor, while a strong steel shield extended over this barbette.

There was a conning tower abaft and above the barbette protected by 6 inch armor. A double bottom extended for about two-thirds of the length of the ship, which was divided into sixty-six separate watertight compartments, of which those next the ship's side were packed with cork. We shall have occasion to notice these facts when we allude presently to the sinking of the King Yuen.

The armament consisted of two 21 centimeter—8¼ inches—Krupp breech loading guns in the barbette, two 15 centimeter—5·9 inch—guns of the same description in sponsons on the beam amidships, seven machine guns, and four Schwartzkopff torpedo dischargers, one in the bow under water and three above water. There was one military mast. Ammunition carried for each of the large guns 50 rounds. The principal dimensions, etc., were as follows: Length, 270 feet; breadth, 40 feet; extreme draught, 16 feet 6 inches; displacement, 2,850 tons. The engines were triple expansion, to develop 3,400 horse power, giving a speed of 15½ knots with natural draught and a speed of 16½ knots with forced draught. The boilers were cylindrical and four in number. The coal storage 335 tons.

The two twin screw steel protected cruisers, Chih Yuen, sunk at Yalu, and Ching Yuen, were laid down at Elswick in October, 1885. The first was launched on the 29th of September, 1886, and the second on the 14th of December, 1886. They were completed and went out with the two ironclads built at Stettin, in September, 1887.

They had a turtle-back steel armored deck from 2 in. to 3 in. thick, and a double bottom beneath the machinery. Two 8 in. 12 ton guns were coupled in the bows upon a Vavasseur mounting, which was protected by 12 in. of steel and a protective shield. A third 8 in. gun was at the stern, while a 6 in. 4 ton gun was sponsoned out on each broadside. They also carried seven 57 mm., two 47 mm., and eight 27 mm. quick firing guns, six machine guns and four torpedo tubes. The dimensions, etc., were as follows: Length, 250 ft.; breadth, 38 ft.; draught, 15 ft.; displacement, 2,300 tons. The engines were triple expansion, designed to develop 5,500 horse power, and the estimated full speed was 18 knots. Coal capacity 450 tons.

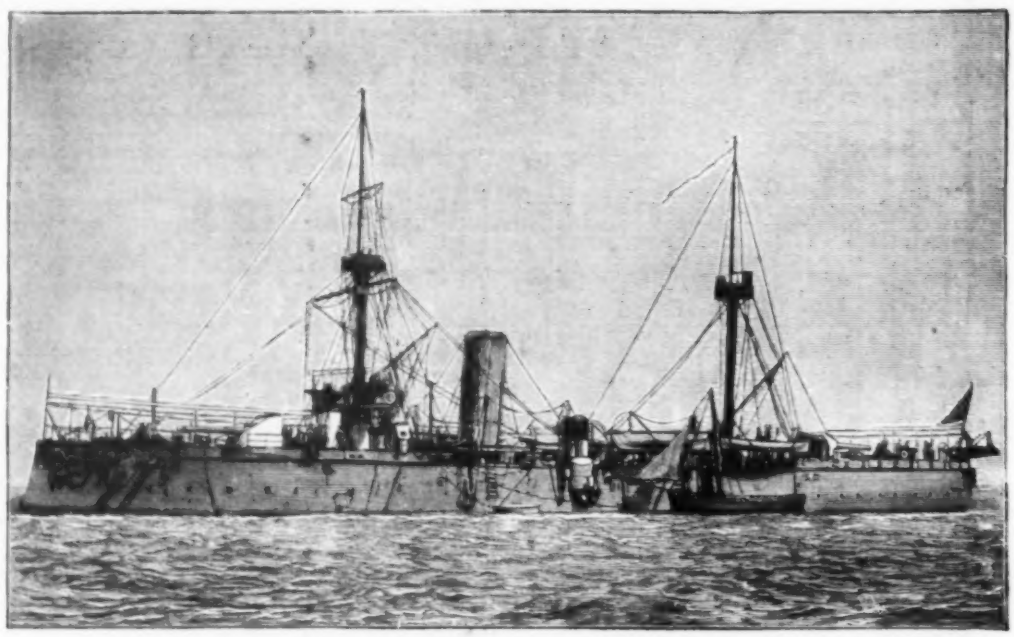
A graphic description was given by the flag lieutenant of the Japanese admiral of the way in which the King Yuen was fought by her Chinese captain, and her subsequent going down. The error which was made by the Japanese in mistaking her for her sister ship, the Lai Yuen, is obvious. We have necessarily transposed the names. The report ran as follows: "After a time the Chinese admiral apparently became desperate. His formation was broken and two or three of his ships advanced against us at full speed." Apparently the King Yuen and Chih Yuen. "The fighting became furious, but our weight of metal told, and one ship, the King Yuen, was crippled in this venture. When the Chinese resumed their line formation our guns were directed upon the disabled ships, particularly the King Yuen. She had been riddled by shot and shell, and it was evident that she was sinking. The Chinese gunners worked their weapons to the last. Finally she went down slowly stern first. Her bows rose clean out of the water, and she remained in this position for a minute and a half before she disappeared in one last plunge. We had used no torpedoes upon her, but sank her by fair shot and shell fire. It spurred all our men to additional effort, and the officers were naturally exultant. They regarded the sinking of a double bottom ship like the King Yuen by gun fire alone as no mean achievement." No more valuable testimony than this—the report of an enemy—is necessary to afford proof of the gallant conduct of the crew of the King Yuen. The Chinese report is laconic. The unfortunate vessel was in a terrible plight, rolling heavily, "when a shell burst through her decks, and with the flames bursting out of her she slowly settled down."

Two conflicting accounts are given of the destruction of the Chih Yuen. The first is as follows: "The Chih Yuen, which still bravely fought her guns when she was nothing more than a wallowing wreck, was struck by a torpedo, and went down with the brave men on board her." The second, also from a Chinese source: "Late in the afternoon the Chinese Armstrong built cruiser Chih Yuen, whose captain had several times displayed a disposition to disregard the admiral's signals, deliberately steamed out of line, although again ordered to remain in the spot assigned to her, and went full speed at a Japanese cruiser. The latter received a slanting blow, which ripped her up below the water line and she soon foundered. But she delivered several parting broadsides at her enemy at close quarters before she sank. The Chih Yuen was so injured by the cruiser's guns and by the effects of the collision that she also sank." It is probable that the latter account is the correct one, as the Japanese admiral positively asserts that "no torpedo was fired" by any of his vessels during the whole of the action.

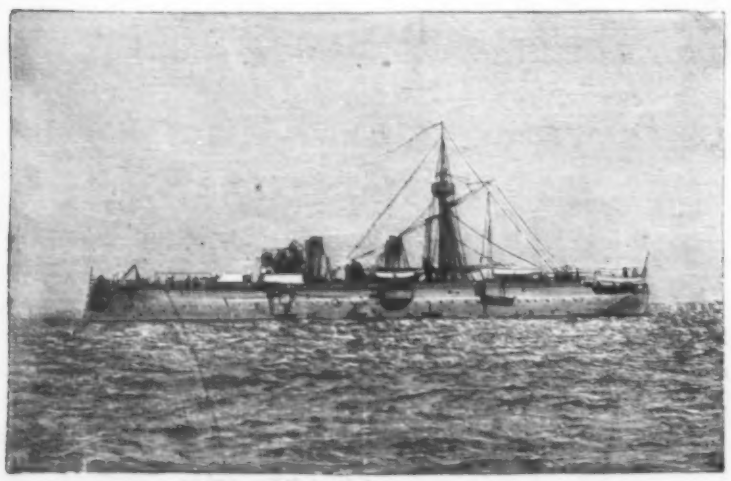
Only one ship, therefore, appears to have been sunk by gun fire alone, the King Yuen. Probably she had been hulled over and over again beneath and upon the water line, when she rolled and exposed her bottom. Her sixty-six separate compartments failed to keep her afloat. It would be interesting to know whether, in the exigencies of service during the fight, the watertight doors had to be left open. Reports say that the pumps of all the vessels were working furiously, and this shows that the engines and boilers were intact. It is possible that the one shell particularly alluded to, which burst through the deck, after which the vessel settled down, may have gone into and wrecked the engine or boiler rooms. The stoppage of the pumps would necessarily have hastened the foundering of the vessel.

Whether, however, the vulnerability of the King Yuen was due to the thinness of the protective deck over the vitals—that being only 1½ in.—or to failure of the watertight door system, or to the awful concentration of the efforts which were made to sink her, the fact remains that she did go down under gun fire alone. In this connection it may not be inopportune to quote some remarks which were made by an officer on board of her at Spithead in September, 1887. He was drawing a comparison between her and her sister ship and the Chih Yuen and Ching Yuen turned out by Elswick. The two latter he pronounced to be splendid and powerful cruisers, finished in every respect, while the King Yuen and Lai Yuen were incomplete shells. On inspection, it did certainly appear that there was justice in his remarks.

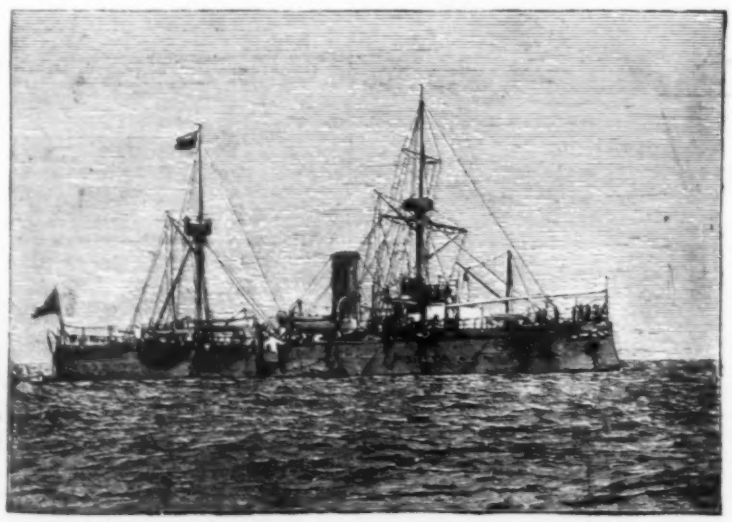
The sinking of the Chih Yuen was clearly due to the folly of employing her as a ram. She was eminently unsuited to such a purpose, and the only wonder is not that she did eventually go down when assailed by a storm of projectiles in her crippled condition, but that she floated at all after her concussion with the enemy. In later vessels of the cruiser class the solid ram bow is not only re-enforced in strength by phosphor bronze longitudinal projections, which are built into the cellular mass behind the forefoot, but the armored deck curves down, and is associated with the stem so as to stiffen the whole to a very great extent. The earlier cruisers, however, were too tender in the stem to admit of their sustaining the severe shock of ramming without serious injury. Hence we are of opinion that the Chih Yuen was lost by the mistaken policy of her cap-



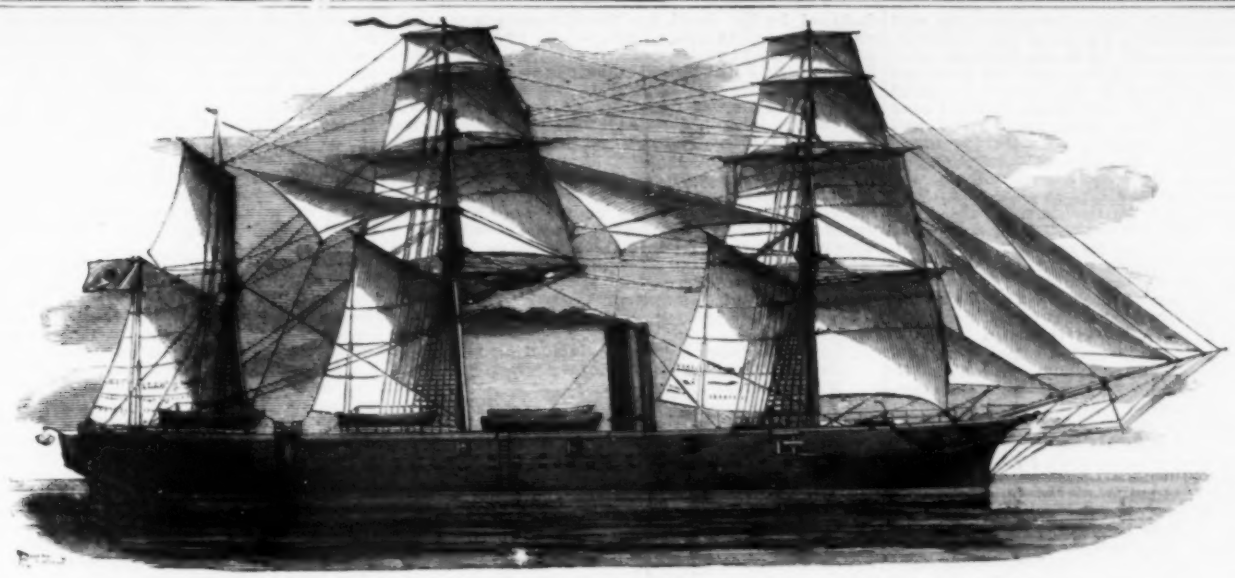
THE CHINESE PROTECTED CRUISER CHIH YUEN, SUNK AT THE BATTLE OF THE YALU.



THE CHINESE IRONCLAD BATTLE SHIP KING YUEN, SUNK AT THE BATTLE OF THE YALU.



THE CHINESE PROTECTED CRUISER CHING YUEN, ENGAGED IN THE BATTLE OF THE YALU.



THE JAPANESE CRUISER HI-YEI, ENGAGED IN THE BATTLE OF YALU.

tain, who appears from all accounts to have been a rash and ill-advised though undoubtedly courageous sailor.

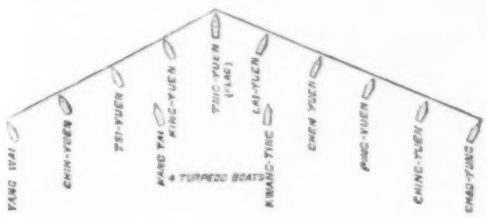
Appended is a list of vessels which took part in the action, both on the Chinese and Japanese sides, and remarks are made in the margin as to their subsequent condition, so far as can be ascertained at present:

CHINA.

Ships.	Displacement.	Armament. Heavy.	Armament. Small.	Speed.	Remarks.
ARMORED.	Tons			Knots.	
Chen Yuen.....P.3"	7430	6	8	14·5	Belted. Disabled.
King Yuen.....P.3"	2850	4	7	16·5	Do. Sunk.
Lai Yuen.....P.2"	2850	4	7	16·5	Do. Caught fire; much damaged.
Ping Yuen.....P.2"	2850	3	8	10·5	Do.
Ting Yuen.....P.3"	7430	6	8	14·5	Do.
UNARMORED.					
Chih Yuen.....P.1"	2300	5	28	18·0	10" steel armor on barbette. Sunk.
Ching Yuen.....P.4"	2300	5	23	18·0	Do. Hulked badly.
Kwang Kai.....P.1"	1030	3	8	16·5	One of these subsequently said to be destroyed.
Kwang Ting.....P.1"	1030	3	8	16·5	
Tshao Yung.....	1350	6	7	16·8	Destroyed.
Tsi Yuen.....P.4"	2355	3	9	15·0	Disabled.
Yang Wai.....	1350	6	7	16·0	Destroyed.

And four torpedo boats.

The crushing damages that the Chinese squadron sustained are only too apparent. The Kwang Kai and the Kwang Ting, which were up the river with the transports when the Japanese appeared in sight, are the only vessels not reported to be injured, yet one of these was afterward found on shore and torpedoed. The position of the Chinese was approximately thus, at first:



JAPAN.

Ships.	Displacement.	Armament. Heavy.	Armament. Small.	Speed.	Remarks.
ARMORED.	Tons.			Knots.	
Foo So.....	3718	6	5	13·2	Iron ship, old.
Hi-yei.....	2200	9	—	13·0	Old. Disabled.
Tschiyoda.....P.1"	2450	24	3	19·0	New.
UNARMORED.					
Akagi.....	615	2	2	12·0	
Akitsuschima.....P.	3150	13	6	19·0	
Hasidate.....P.2"	4277	12	12	17·5	12" steel on barbette.
Itsukusima.....P.2"	4277	12	12	17·5	Do.
Matsuchima.....P.2"	4277	12	12	17·5	Do. Disabled.
Naniwa.....P.3"	3650	8	12	18·72	
Takachiho.....P.3"	3650	8	12	18·72	
Yoshino.....P.4½"	4150	12	12	23·05	Much injured.

The Sakiomaru was accidentally present in the engagement, and appears to have suffered severely, if not sunk. It seems, thus, that while no vessels were actually lost by the Japanese, except possibly the Sakiomara, three were either disabled or terribly injured; and, as the only reports upon their actual condition have been received from Japan, the whole truth may be much more serious than is admitted to be the case. But, clearly, China has come out of the action very much the worst.

A British naval officer attached to the Chinese naval squadron which was engaged in the fight off the mouth of the Yalu River has written a letter to the Graphic, in which he gives additional details of the fighting, and says:

"On board the war ship Chen Yuen the fighting was awful. The decks and the space around the guns were strewn with human fragments. Three of five men working a four ton gun were blown up by a shell from the Japanese war ship Naniwa. The fourth gunner was shot while trying to escape from the turret and the fifth stuck to his post.

"This man fired three rounds at the Naniwa, one shell entering the engine room of the Japanese ship and another smashing her forebridge. The Naniwa then hauled off. The Chinese admiral rewarded the surviving gunner with a present of 1,000 taels.

"A shell glanced from the steel deck of the Chen Yuen and went through her tower, shattering everything therein. A lieutenant, who was in the act of speaking through the tube leading to the engine room, was blown into atoms, and his head was left hanging to the speaking pipes. Huge fragments of armor and the teak backing thereof were carried inboard by the shot, crushing a large number of sailors into a shapeless mass.

"A European engineer who was in the act of groping about in an endeavor to repair a steam pipe was drenched from head to foot with the blood of an assistant who was disemboweled by his side by a shot from the enemy's ship.

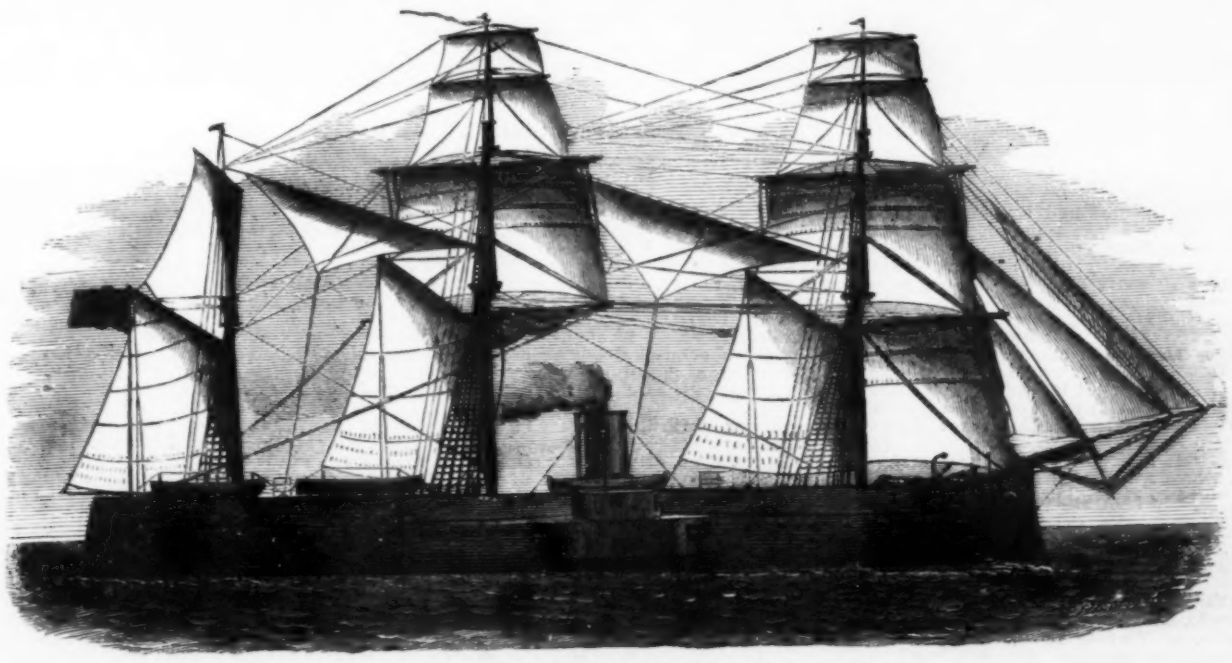
"The Chen Yuen arrived at Wei-Hai-Wei the day after the fight in the same condition in which she left the battle. No attempt has been made to wash the blood from her or to remove the corpses which strewed her decks."

The writer expresses the opinion that if the European rulers could have seen the decks of the Chen Yuen they would have foresworn war henceforth and forever.

The following particulars of the Chinese ships were given in the Illustrated London News in 1887, at the time of the completion of the vessels:

"A squadron of five new vessels of war constructed by British and German shipbuilders for the Chinese navy, and commanded by Admiral Lang, an officer of the royal navy holding the rank of captain in her Majesty's service, recently left Spithead for China. It consists of two swift 'protected cruisers,' the Chih Yuen and the Ching Yuen, built at Elswick, Newcastle-on-Tyne, from designs by Mr. W. H. White, of the firm of Sir William Armstrong, Mitcheli & Co.; two armored cruisers, the King Yuen and the Lai Yuen, built at Stettin, on the Baltic, by the Vulcan Shipbuilding Company; and one torpedo boat, built by Messrs. Yarrow & Sons, of Poplar, under a contract with Messrs. John Birch & Co., of Liverpool.

"The Chih Yuen and the Ching Yuen have been constructed under the superintendence of Liu Ta-jen, the present Chinese minister. Their displacement is 2,300 tons, the length is 268 feet, breadth 38 feet, and depth from the main deck to the keel moulded 21 feet. The draught forward is 14 feet, and aft 16 feet. Each vessel has two pairs of triple expansion engines, constructed by the firm of Messrs. Humphrys, Tennant & Co. Both the engine and boiler rooms are divided into watertight compartments by transverse and longitudinal bulkheads, and the machinery is so arranged that either boiler can work on either engine or on both, and the change can be carried out while the vessel is in motion. On the four trial trips, two with and two against the tide, with all their weights, armament, and Chinese crews on board, they attained an average speed of 18·536 knots. The material of each vessel is steel. There are two decks, the lower one being of the turtle back form, consisting of 4 inch steel



THE JAPANESE IRONCLAD FOO-SO.

plates rising in the middle above the water line, and inclined at the sides so as to dip some feet below it. The engines, magazines, rudder head, steering gear, and all the important parts of the vessel are protected by this deck. The openings in the deck are encircled by cofferdams, protected by steel plates, inclined so as to deflect the shot. The bows are formed and strengthened for ramming purposes. On the turtle deck, running parallel to the sides of the vessel, is a partition, inclosing a space between itself and the side. This space is subdivided into a great number of watertight compartments for the reception of coal or patent fuel. An additional protection of a layer of coal, about 8 feet in thickness all round, is thus given to the vessels. The bunker accommodation is 450 tons. Both ships have double bottoms.

"The armament consists of three 21 centimeter Krupp guns, two 6 inch Armstrongs, eight 6 pounder rapid firing Hotchkiss guns, and six Gatlings. Of the Krupps, two, which are placed in the bows, are mounted on Vavasseur carriages, on revolving platforms, protected by splinter proof shields, and one, which is in the stern, is also placed on a Vavasseur carriage revolving on a center pivot. In both cases the guns are moved by means of hydraulic machinery. The Armstrongs, likewise, move on center pivot Vavasseur carriages, and are placed on sponsons at the side of the vessel, so as to allow of the training of the guns over a very large arc, about 100°. These likewise are protected by 2 inch steel plate splinter proof shields. The torpedo armament consists of four above-water torpedo guns, one, fixed in the bow, firing right ahead, one right astern, and two training guns are fixed in each broadside forward. There are two electric search lights for each vessel, of a nominal power of 25,000 candles. Each has a conning tower of 3 inch steel plates, from which the working of the ships, guns, and torpedoes can be directed. An important addition is an armor plated tower, for the protection of the signalman, which was suggested by Admiral Lang. The guns are provided with converging fire apparatus, so that they can be fired singly or simultaneously.

"The torpedo boat built by Messrs. Yarrow is said to be the fastest of its size that has ever been launched. It has reached the great speed of about twenty-eight miles an hour. It is armed with two fixed 14 in. torpedo guns in the bows and one 14 in. training gun on deck abaft the funnel. It is also supplied with a powerful armament of Hotchkiss and Gatling guns and a strong electric search light.

"The two vessels built in Germany are of the class of armored cruisers. Their speed is under sixteen knots. They are armed with two 21 centimeter Krupp guns and two small guns."

In 1878 the building of warships for Japan was intrusted to English contractors, and the description of the vessels then given in the Engineer, London, was as follows:

The ships are three in number and are named respectively the Foo-So, Kon-go, and Hi-Yei, the names of mountains in Japan. We take the Foo-So first in order as being the most important. She is a broadside ironclad vessel of somewhat similar type to those designed by Mr. Reed for the Chilean government, and completed in this country about two years ago, and also somewhat similar to, but much more powerful than, the Fethi-Bulind and Mukademme Kies, two Turkish vessels also built from the designs of Mr. Reed, when he was Chief Constructor of the Navy, and which have performed excellent service during the present war. The Foo-So, although but little larger, has been made much more formidable than the Turkish ironclads referred to, by means which the later date of her design has rendered practicable. She has, in addition to the main deck battery, an upper deck battery carrying two guns of 17 centimeters bore with fire right forward and aft, and commanding the whole horizon, and her armor is attached to the hull in a novel manner, which is described further on.

The following are her principal particulars:

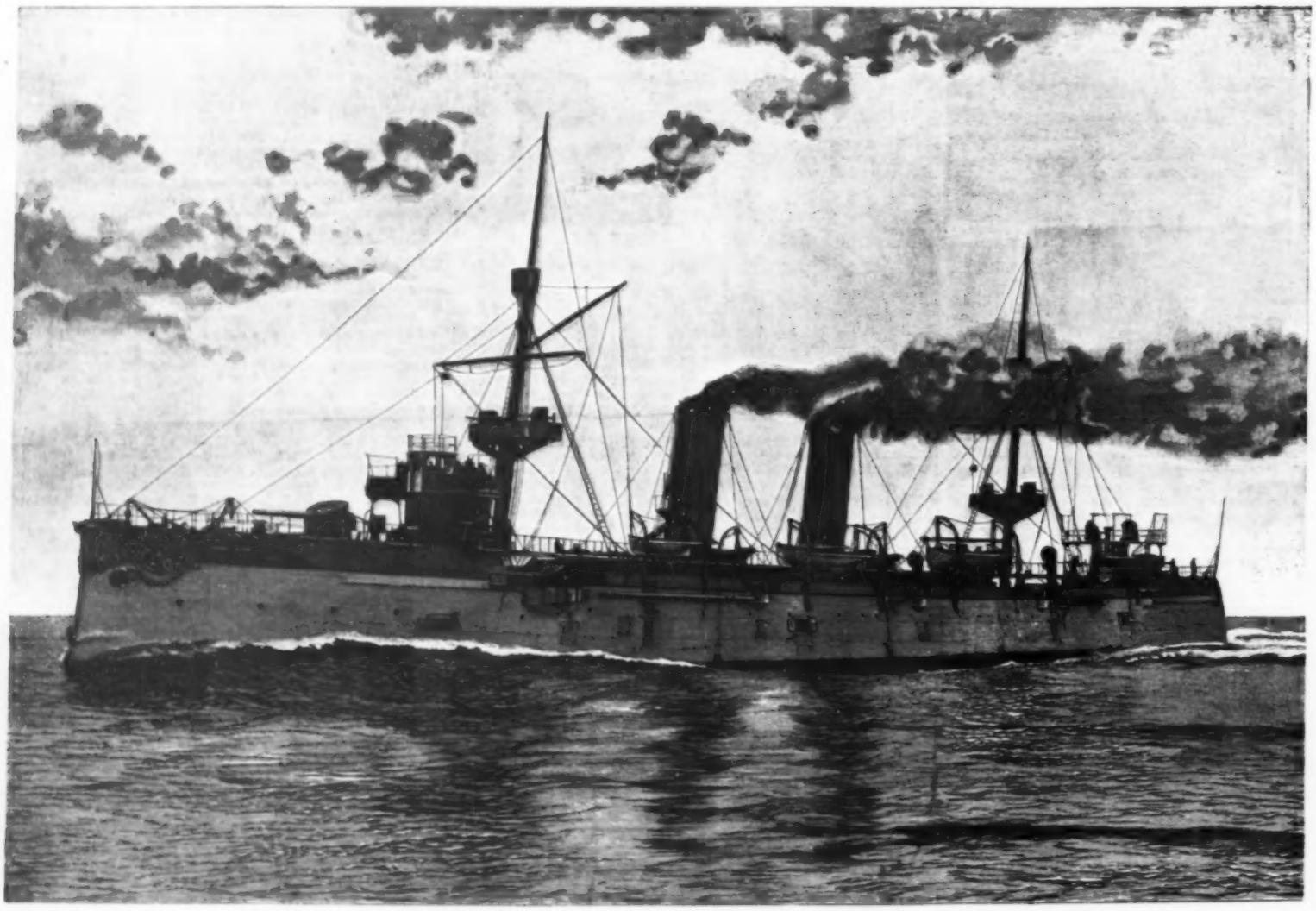
		Ft.	In.
Length between perpendiculars		220	0
Breadth, extreme		48	0
Depth in hold		30	4½
Draught of water,	Forward	17	9
	Aft	18	3
Height of port from low water line		8	6
Displacement in tons		3,718	
Indicated horse power		3,500	
Speed in knots		13	
Complement of men and officers		250	
Armament.	Main deck battery, four 24 centimeter guns.		
	Upper deck battery, two 17 centimeter guns, to fire forward and aft.		

The vessel is armed with Krupp guns of the dimensions stated above, and it will be seen that they are disposed on the central battery system, the armor on the sides of the battery being 9 in. thick and on the athwartship bulkheads 8 in.; access to the battery from the fore and aft parts of the main deck being by means of armored doors. The guns on the main deck, four in number, have a weight of about 15¼ tons each, and, being fitted on the embrasure plan, command the broadside, and within 30° of the fore and aft line; the guns on the upper deck weigh about 5½ tons each and commanding, as already said, the whole horizon, must be of great value as chase guns and for various other purposes.

The machinery of the Foo-So consists of two pairs of compound horizontal surface condensing trunk engines by Messrs. Penn, driving twin screws 15 ft. 6 in. diameter. The boilers are eight in number, of the cylindrical type, working at 60 lb. pressure; each is 11 ft. 3 in. in diameter, and contains three furnaces, each 2 ft. 11 in. in diameter. The armor is supported by brackets attached outside the frame of the ship, thus allowing a clear line from floor to deck for the frame, and avoiding all the expensive and often unsatisfactory work of the armor shelf as hitherto constructed. The projecting edge of the armor will further act as a bilge keel to reduce the rolling. The iron floating batteries built for the Crimean war were similarly constructed, but this is the first instance in which Mr. Reed or any constructor has applied this improvement to sea-going ships; and it appears to have the advantages of cheapness and expedition in building, especially as the bending of the armor plates to the vertical curvature of the ship is in this case avoided. That the first advantage exists is self-evident, and the existence of the last is proved by the fact that Messrs. Samuda, with whom the contract was placed, completed the framing and plating of the vessel in a very short time. The Foo-So is bark-rigged, and is extremely handsome in appearance; she will, no doubt, be very handy also, her speed being high in proportion to her size, and her length being little more than four and one-half times her beam.

The Kon-go and Hi-Yei are sister vessels, the Kon-go being built by Earles' Shipbuilding and Engineering Company, of Hull, and the Hi-Yei by the Milford Haven Shipbuilding and Engineering Company, Pembroke Dock; the engines for both these ships being supplied by the first named company. The leading features of the light unarmored composite corvettes of the Gem class lately introduced to the British navy are now well known, and it was thought desirable to supply the Japanese navy with two vessels of this general type, but some very material modifications and improvements were obtained by means of some increase of size.

The vessels for her Majesty's navy are in the latter examples 220 ft. long, 40 ft. beam, and about 17 ft. 6 in. draught, armed with fourteen 64 pounder (64 cwt.) guns on the upper deck, capable of firing 2° across the bow line forward and 2° across the central line aft; they have a speed of about 13 to 13¼ knots, horizontal compound engines of 2 100 indicated horse power, a



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The vessel is armed with Krupp guns of the dimensions stated above, and it will be seen that they are disposed on the central battery system, the armor on the sides of the battery being 9 in. thick and on the athwartship bulkheads 8 in.; access to the battery from the fore and aft parts of the main deck being by means of armored doors. The guns on the main deck, four in number, have a weight of about 15¼ tons each, and, being fitted on the embrasure plan, command the broadside, and within 30° of the fore and aft line; the guns on the upper deck weigh about 5½ tons each and commanding, as already said, the whole horizon, must be of great value as chase guns and for various other purposes.

The machinery of the Foo-So consists of two pairs of compound horizontal surface condensing trunk engines by Messrs. Penn, driving twin screws 15 ft. 6 in. diameter. The boilers are eight in number, of the cylindrical type, working at 60 lb. pressure; each is 11 ft. 3 in. in diameter, and contains three furnaces, each 2 ft. 11 in. in diameter. The armor is supported by brackets attached outside the frame of the ship, thus allowing a clear line from floor to deck for the frame, and avoiding all the expensive and often unsatisfactory work of the armor shelf as hitherto constructed. The projecting edge of the armor will further act as a bilge keel to reduce the rolling. The iron floating batteries built for the Crimean war were similarly constructed, but this is the first instance in which Mr. Reed or any

large spread of canvas, steer well, and are very handsome. They have, however, no protection above the water line for their machinery, excepting such as is afforded by the stowage of coal in the wing bunkers; this protection, however, is not of a permanent character and is liable to disappear after the vessel has been some time at sea. The weight of coal carried is about 340 tons. The Japanese vessels are 231 ft. long, 40 ft. 9 in. beam, and 17 ft. 6 in. draught, armed with six 15 centimeter (about 4 tons) Krupp guns on the broadside, two guns of 17 centimeters bore (about 5½ tons) at the bow, capable of firing either right ahead or 32° abaft the beam, and one 17 centimeter gun at the stern, capable of a range from right astern to 35° forward of the beam. They have horizontal compound engines of 2,500 indicated horse power, and have also a large spread of canvas; indeed, the rig of all the three Japanese vessels has been made as nearly as possible the same, in order to make any of the spare spars, rigging, or stores available for either ship. The corvettes each carry about 280 tons of coal. In order to secure the power of fighting the gun right aft, Mr. Reed has not adopted the poop and the apparatus for lifting the screw from the water fitted to the British ships. In the case of the latter the guns can fire only within an angle of about 2° across the fore and aft line except by removing the gun from side to side of the ship. The abolition of the screw lifting gear will undoubtedly simplify the arrangement of the machinery astern, and

disconnecting gear to allow the free revolution of the screw when the vessel is under sail is provided. On one important point the Japanese vessels have great advantage, that is as regards boiler space; their greater length as compared with the British ships has enabled much larger boilers to be fitted, and, as much of the difficulty experienced with the machinery of the Tourmaline and her sister vessels appears to have sprung from priming, owing to insufficient steam space, it is confidently expected that much more satisfactory results will be developed in the trials of the Japanese vessels. The speed expected from them is 13½ knots, but judging from the beautiful lines of the vessels and their large engine power, it is not unlikely that this estimate will be considerably exceeded.

One of the most important features of the Japanese corvettes yet remains to be mentioned, and that is a belt of armor 4½ in. thick extending along the ship at about the height of the water line; this belt is embedded in the wood sheathing of the ship, being covered by an outer thickness of plank 3 in. thick, thus avoiding any obstruction to sheathing the vessels with copper in the usual way. In addition to the armor protection there is also that afforded by the coals which surround the magazines and boilers, but, as we have said, this latter protection cannot be depended upon in the later stages of the vessel's cruise. The Kon-go and Hi-Yei are certainly in appearance the handsomest vessels intended for war purposes which we have ever seen; they are more like yachts than men-of-war, and this fact may be taken as a proof that fighting power does not in all cases involve the ugliness of which so many naval critics have complained.

The Yoshino.—In the battle of Yalu the Yoshino made terrible havoc on board the Chinese vessels. The following description of the Yoshino, finished in February, 1894, is from the Engineer, London:

Our engraving illustrates the Japanese protected cruiser Yoshino running at her top speed, twenty-three knots. Our engraving has been prepared from an instantaneous photograph, for which we are indebted to Messrs. Sir W. Armstrong, Mitchell & Co., of Elswick. She is the fastest sea-going vessel in the world—faster a good deal than anything in the United States navy. Within the last two weeks she has left this country for Japan, and the reports which have been received leave no room to doubt that she is an exceedingly good sea boat as well as a powerful war ship. It is to be regretted that she belongs to a foreign government instead of to the British navy.

The Yoshino is the same class of vessel as the 9 de Julio and 25 de Mayo, constructed by the same firm for the Argentine government, but exceeds either of them in size and speed, and is, moreover, provided with a double bottom, which they have not. The results of the speed trials carried out last July off the mouth of the Tyne far exceed any yet obtained from a sea-going vessel, and prove her to be the fastest cruiser now afloat, a fact having this significance, that there does not exist anything in the form of a ship that could escape from her if pursued. The Yoshino is 350 ft. long, 46½ ft. broad, and her displacement at load draught is about 4,000 tons.

During the natural draught trials the ship attained a mean speed of 21·6 knots, with forced draught 23·031 knots, or 26·51 miles per hour. At the turning trials it was shown that the ship could turn through 360 deg. in three minutes and eight seconds; the diameter of the circle measuring 375 yards. This was considered a remarkably small circle for a vessel of the length of the Yoshino. The helm could be put from hard-a-port to hard-a-starboard in thirteen seconds, and the engines could be reversed from full speed ahead to full speed astern in a few seconds. The vessel thus possesses in a very high degree the handiness and maneuvering power which are so essential to a cruiser of this class.

The armament of the vessel consists of four 6 in., eight 4·7 in., and twenty-two 3 pounder quick-firing guns, and five torpedo tubes. One 6 in. gun is placed on the forecastle and one on the poop, each gun being capable of firing through an arc of 270 deg., or all round the bows to 45 deg. abaft the beam on either side for the forward gun, and round the stern to the same angle before the beam on both sides for the after gun. The other two 6 in. guns are carried in sponsons at the level of the upper deck, one in each bow, and have a range of fire from 3 deg. across the bow to 60 deg. abaft the beam. The eight 4·7 in. quick-firing guns are carried in sponsons at the level of the upper deck, the aftermost pair being close to the poop, and firing from 3 deg. across the stern to 60 deg. before the beam, and the other six—three on each side—have each a range of 120 deg. The twenty-two 3 pounder quick-firing guns are disposed as follows: Two at the after end of the forecastle—one on each side—so as to get a training arc of about 80 deg. abaft the beam, and two similarly placed on the poop; four are placed in the military tops, two in each; eight on the upper deck bulwarks, and the remainder between decks, thus obtaining a complete command of every possible direction of approach to the ship. One of the torpedo tubes is in the stem for right ahead fire, the other four are training tubes, and fire on the broadside, two being placed in a chamber forward on the main deck, immediately before the machinery compartments, and the other two in a similar chamber aft of those compartments. Her machinery—as was to be expected—coming from Messrs. Humphrys, Tennant & Co., worked most satisfactorily throughout the whole of the trials, and the Japanese government may be congratulated on the possession of one of the finest, swiftest, and most powerful war ships of her class afloat.

THE OIL-BURNING LOCOMOTIVE PETROLIA.

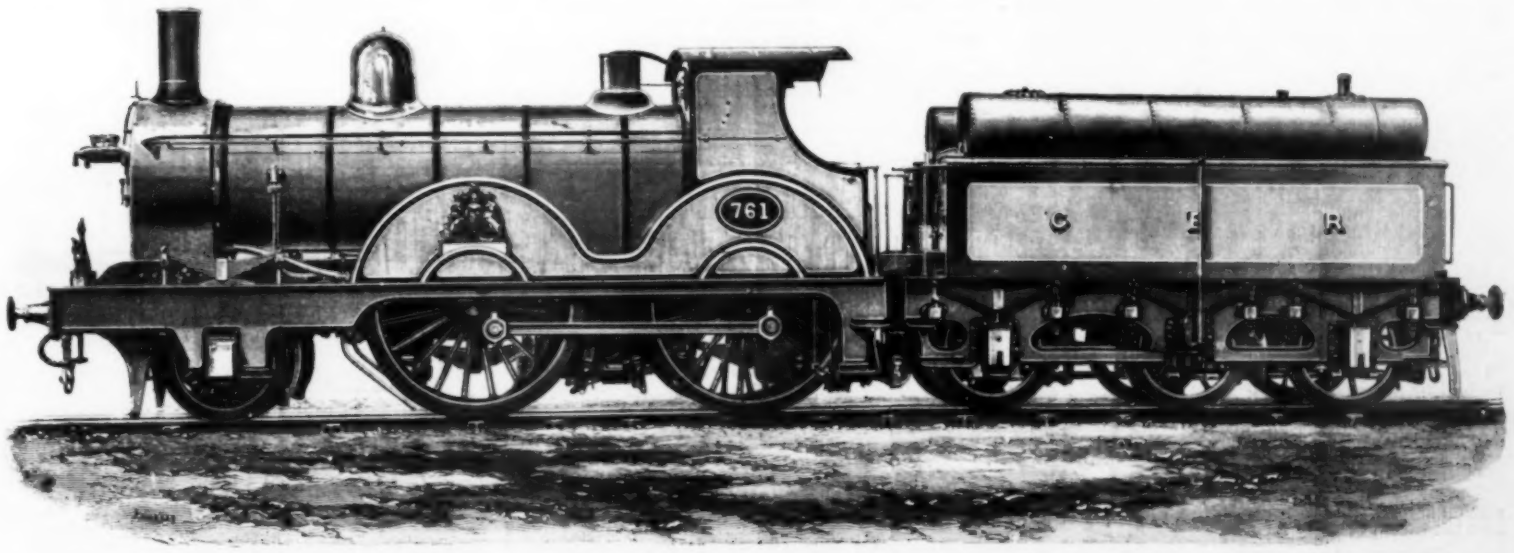
THE driving wheels of the engine are 7 ft. diameter, the leading wheels 4 ft. diameter, and the cylinders 18 in. by 24 in., cast in one piece, with the valves underneath. The link motion is of the Stephenson type. In the boiler there are 256 steel tubes 1⅝ in. diameter. The shell is of steel plates ⅝ in. thick, the firebox of copper, the heating surface 1,230 square feet, the grate area 17·9 square feet. The total weight of the engine in running order is 42 tons, and that of the tender in running order is 32 tons. The liquid fuel burning apparatus is placed below the foot board, so as not to interfere with the ordinary working of the locomotive. Further, the fire bars, etc., remain, and are available for coal firing, either for lighting up and raising steam, or for ordinary coal burning, should it by accident or design become necessary. The injectors—described later—face two holes provided through the fire box casing, about 12 in. above the fire bar level.

The usual practice on the Great Eastern Railway is to keep the fire bars covered with an incandescent base of solid fuel, limiting the combustion by partially closing the damper; the air necessary for the oil fire is introduced by the action of the ring blower of the injector above the solid fuel base, and as the spraying and distribution are also effected by the steam jets, no exceptional firebrick is required.

For fuel, oil, and coal gas tars, creosote oils and petroleum residues are used. With any of these, if fair samples, one ton will replace nearly two tons of coal. This difference in favor of the oil fuel is not only to be attributed to the higher calorific value of it, but also to the fact that very complete combustion can be secured, and no unnecessary air need be admitted at the fire door, as usually occurs at intervals of firing with a coal fire. In addition, the fire can be exactly regulated to meet requirements.

The liquid fuel is carried in two cylindrical tanks on the tender, with a combined capacity of 600 gallons. From these it is conveyed by pipes and a flexible connection to the engine. Here branch pipes are provided to each burner with regulating valves working through spindles from a convenient position. Liquid fuel can be simultaneously admitted or shut off at both injectors by one horizontal movement of a handle, or the fuel can be regulated and controlled to either one of the injectors by turning milled heads. On reaching the injector the fuel is sprayed by an internal annular steam jet. This steam, as it escapes from its orifice to receive the fuel, sets up a strong induced current through a central air tube. The vacuum pipes can be put into communication with air-heating coils in the smoke box, thus supplying hot air to the centers of the injectors for combustion. The fuel spray escaping from the nozzle of the injector is further atomized by the small jets of steam arranged around the ring of the burner, at the same time the ring acts as a blower, inducing atmospheric air for complete combustion, and further it spreads and diffuses the flame and heated gases over the fire box. Steam is obtained from a fitting on the fire box front, having an internal pipe to the dome. There are four cocks, one for steam to the central jets of the injector, one for the ring blower on the same, one for steam to the warming coils in the oil tanks, and one for allowing a steam jet to enter the oil pipes for cleaning purposes.

In consumption of fuels, the liquid fuel burners for a month's average of over 3,000 miles burn: Coal for lighting up, standing, etc., 11·8 lb. per mile; liquid fuel, running, 10·5 lb. per mile; total, 22·3 lb. per mile. This compares favorably with a consumption of 34 lb. per mile of coal on similar engines on same service. On June 15, 1894, engine No. 761 ran through from London—St. Pancras—to Scarborough and back, with a special train of saloons, dining car, etc., weighing 200 tons. The total distance is 534 miles, and consumption of fuel 11·5 lb. of coal per mile and 11·25 lb. of liquid fuel per mile; total, 22·8 lb. per mile. The fire was not cleaned, and the only stoppages made were those required for water and oiling the engine.—The Engineer.



EXPRESS LOCOMOTIVE, BURNING OIL FUEL, GREAT EASTERN RAILWAY.

[FROM THE COLLIERY ENGINEER.]

A TYPICAL GOLD MINE.*

By Prof. ARTHUR LAKES, Golden, Col.

MACHINERY.

THE engine and boiler rooms are side by side, the boiler room occupying a lower level adjoining the engine room. The size of the engine room is 50 feet by 30. The drum of the great hoisting wheel is 7 feet in diameter by 5 feet across horizontally from face to face. The steel wire rope is 1¼ inches diameter.

The steam cylinders incased in wood are 42 inches long and 16 inches diameter. The engine bed is 10 to 12 feet in length. The main shaft is 10 inches in diameter. The engine, which is of the Corliss pattern, was built at the Chicago Iron Works.

The engineer's platform on which the engineer stands to regulate the hoisting is in the middle of the room between the two engine beds, and faces the drum.

The platform contains a brake for the drum, a reversing lever, a foot brake, steam reverser and steam clutch.

A large indicator like a big wheel-faced clock with two hands, one red and one white, indicates the speed and progress of the skip. On the black rim of this wheel are written, like the hours on a clock, the numbers of the different levels. The indicator shows the position of the cage in the shaft. The dial plate is 4 feet in diameter. The red hand indicates all points, and moves slowly. The white hand indicates the last 100 feet of travel to the top of the shaft. It begins to move only when this 100 foot point is reached, and travels rapidly on an increased scale. The indicator is so geared that there is no lost motion. By this instrument the engineer knows exactly where the cage is while he is hoisting. The white hand prevents him from the danger of overwinding. Without this precaution, an engineer might overwind, and raise the skip and its occupants with fearful force to the extreme top of the incline scaffolding, and dash it against the roof timbers. By the white hand beginning to move, however, he knows that they are now within 100 feet of the top and it is time to slacken speed.

The length of the wire rope is 1,250 feet, extending not merely to the bottom of the shaft, but through the sorting room to the engine room, where the rest of it is wound round the grooved surface of the big drum.

For signals, a gong is attached to the wall of the engine room, with a wire down the shaft. At each level a lever is attached to the wire to pull it. The signals are:

Three bells means—hoist!

Two bells means—lower!

One bell means—stop! That is the first general signal.

Then to specialize the particular level or station, other bells follow according to the number of the level or station. Thus:

Six bells, means station number 6. If we want to be hoisted up from there, we first ring 3 bells as a general signal to hoist, and 6 bells to show the level we are at. If to lower, 2 bells and 6, and so on.

As to the power of the hoisting engine. The cylinder is 16 inches and 42 inches stroke. The horse power depends upon boiler pressure. At 60 pounds this is about 300 horse power. The safety catches used are the usual cam clutch with spring attached to the cable.

The engine is guaranteed to hoist 5 tons from a depth of 1,500 feet in one minute.

The average load at present hoisted is:

Rock..... 6,000 pounds.
Mineral..... 10,000 pounds.

The first engine employed on the property under the

* Continued from SUPPLEMENT No. 981, page 15675.

former owner was of 30 horse power, single 10 inch cylinder, 14 inches stroke, slide valve, and raised 1,500 pounds at a load.

Average amount of fuel used was 3 tons of coal per 12 hours. It took half an hour to raise the load from bottom to surface. This, of course, was owing to the compromise vertical incline shaft, dumping, drawing in car, tramming to the vertical and hoisting again to the surface.

The new engine we have described of 300 horse power and double 16 inches × 42 inches raises 6,000 pounds.

Average fuel is 1 ton of coal per 12 hours.

Hoist from the 6th level is 500 feet in ½ minute. Corliss valves and cut off gear reversible, direct acting. One drum 7 feet diameter, with automatic clutch, so that the cage can be lowered independently without steam. The rope is 1⅛ inches round rope, the main bearings are of phosphor bronze and the crank shaft is 10 inches diameter.

BOILER ROOM.

The boiler room is on the ground floor below and adjacent to the engine room.

There are three boilers, two large and one smaller.

The diameter of the larger boilers is 5 feet. The diameter of the larger drums standing above the boilers is 3 feet, and of the smaller 2 feet 6 inches. Connected with these boilers are three large stacks, diameters 3 feet and 2 feet 6 inches. A small cistern stands in a corner fed by small steam pump.

PUMPS.

There are two pumping engines of the Worthington pattern. Their capacity per hour is at the rate of 100 gallons per minute. Their power is 1,000 feet lift, but only lifting 500 feet at present. The pumps run about 4 hours out of 24. The average hoist now is 50 gallons per minute or 416·6 pounds. The sump at bottom of incline, whose size is 25 × 25 × 10 feet, is pumped out once a day.

AIR COMPRESSORS (INGERSOLL).

The air compressors are worked by water power, the water brought by a flume from a higher level up the creek. The tank or "penstock" and engine house are some little distance from the mine, being the nearest point to which water could be conveniently brought.

Water power, when it can be had for such purposes, is much cheaper than steam, requiring neither coal nor additional engineers.

The water from the flume pours rapidly into the penstock. A screen of iron bars is placed before the door of this tank, to keep off rubbish, bits of ice or drift wood. A door also closes or opens the flume into the penstock as desired. This penstock is in a little building to itself on the edge of the bank overhanging the stream. At the bottom of penstock and below the floor of the building, a horizontal Leffel turbine wheel is revolved by the water. This works on an upright shaft coming up through the floor of the room, on which is a cogwheel moving horizontally connected with another cogwheel moving vertically on it, gyrating a long solid shaft which passes across the yard into the air compressor house, and revolves a large "fly" or driving wheel 10 feet in diameter. From this a belt goes over a tightener to the main driving wheel 12 feet diameter. At one end of the room is a large boiler iron air receiver.

The cylinders of the air compressors are 18 inches diameter, 36 inches stroke. They are of 150 horse power and have a capacity of 15 drills at third level. They were manufactured by the Ingersoll-Sergeant Drill Company.

The largest distance to which air is conveyed at one stretch at present is 3,000 feet, although it is conveyed into the breast of every level by branches, laterals, etc.

DEVELOPMENT.

In a recent issue there was shown a complete longitudinal section of the property, along the strike of the vein from north to south.

The shaded portions show the bodies of ore worked out, and that unshaded is presumably the reserves.

The parts where the ore is stoped, or worked out, are in those parts of the vein where development has shown that the largest bodies of ore, or ore "chutes" as they are called, principally occur, so far as at present known.

The section of the workings shows the different long shafts and inclines, and the shorter shafts or winzes up into the stopes. The horizontal lines show the different levels connected with the principal shafts.

In the middle of the picture is the new main incline shaft we have described, and at the bottom of it is the well or tank called the sump, where the waters from the levels and shaft collect, and are pumped out to the surface.

On the south side, some short prospecting shafts are shown, also some of the stopes of the old workings of the Hukill, stoped right out to the surface.

The bed of Clear Creek occupies a depression near the center of the picture. And the dumps from the different levels and shafts are seen sloping down on the surface of the hills, or in the valley and on the banks of the stream. To secure good dumping ground or plenty of room to dump the refuse rock coming out of the mine is one of the first things to be considered in locating a mine.

The average dimensions of tunnels is 7½ by 4½ feet. Dimensions of main incline shaft inside of timbers is —skip road 5 × 4½ feet; ladder way 3½ × 4½; timbers squared 12 inches × 12 inches, squared sets are 5 feet from center to center.

The greatest vertical depth of workings is 500 feet.

The greatest horizontal length 3,000 feet.

The total length of levels approximates 15,500 feet.

Shafts 2,000 feet.

Winzes 3,000 feet.

The average grade of the galleries is 10 inches per 100 feet.

The wood used for timbering is native red spruce.

In the station sets, the regular sets only are used for strength.

The hanging wall plate is left out, the studdles being 15 feet long.

The general timbering is very similar to that given in the excellent article on the Granite Mountain Mine, Colliery Engineer, December, 1893.

THE MAIN INCLINE SHAFT.

Fig. 16 is from a photograph of the incline shaft, whose slant is 25 degrees from the vertical, Fig. 16

FIG. 16.—FROM A PHOTOGRAPH OF INCLINE SHAFT.

shows the full length of the shaft and Fig. 17 shows its plan and vertical section.

The timber is cut 12 inches × 12 inches square set.

Center piece	6 inches × 12 inches.
Studdles	12 inches × 12 inches.

Sets are 5 feet from center to center, and lagged with 3 inch plank.

Each set is drawn together with bolts, drawn to place

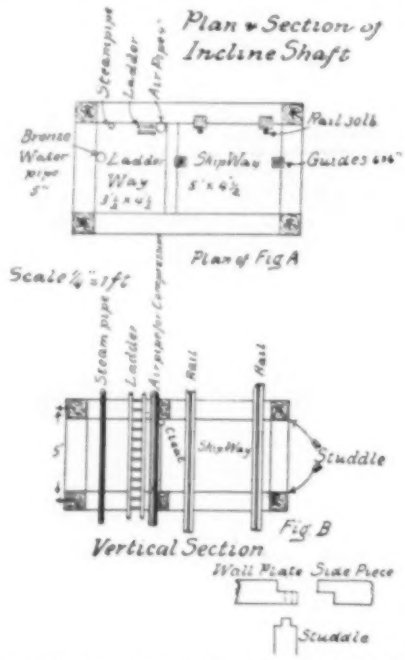


FIG. 17.—PLAN AND VERTICAL SECTION OF SHAFT.

lined and wedged up. The bolts are then withdrawn from the third lowest set or reversed.

MISCELLANEOUS ITEMS.

The number of miners at present is 75; surface workmen, 10; one foreman and one shift boss; length of working shift, 9 hours; number of shifts is two; wages per shift $2.50 to $3.00; cost of sinking shafting is $20.00 per foot; drifting on levels, air drill, $3.00 per foot; drifting is by contract, stoping by day's pay; cost of timber stulls, not less than 12 inch tips and 16 feet long, is $1.00; of lagging, 6 inch tips and 16 feet long, 30 cents; lumber, $15.00; fuel coal $3.00 per ton; iron, 3 cents per foot; steel, 9 cents; atlas powder, 13 cents; candles, $4.00 per box; cost of mining a ton of ore, $2.00.

THE INVENTION OF WATER GAS.

THE question is sometimes asked, Who was the inventor of the process of making water gas, now so extensively used? We believe the credit is due to a Frenchman. We here give a copy of the United States patent granted to Georges Michiels, improvement in manufacture of gas, specification forming part of letters patent No. 4,789, dated October 3, 1846.

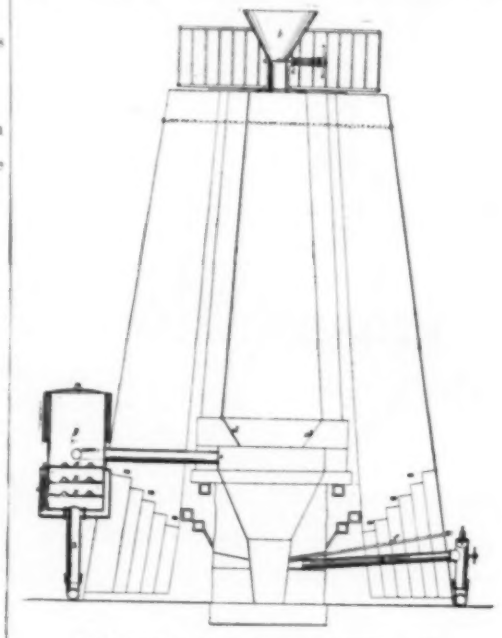
To all persons to whom these presents shall come: Be it known that I, Georges Michiels, of Paris, in the kingdom of France, but now residing in the island of Guadaloupe, have made a certain new and useful invention of improvements in the manufacture of gas, for lighting and heating, and I do hereby declare that the nature of the same is fully set forth and represented in the following specification and accompanying drawings, letters, figures and references thereof.

The invention consists of a mode of manufacturing gas (which I term oxide of carbon) for the purposes of light and heat, by causing anthracite coal (or other equivalent), when in a state of combustion, to be subjected to streams of air and steam so as to produce gas, and, in order that the invention may be most fully understood and readily carried into effect, I will proceed to describe the means pursued in carrying the same into practice.

The furnace for the making of gas, according to this invention, is similar in construction to a blast furnace employed in making iron from ironstone mine or ore, with only slight modifications, to adapt the same to the purpose of gas making from anthracite coal, by applying thereto streams of air and steam.

The drawing above mentioned shows a vertical section of a blast furnace, constructed suitably for carrying out the invention.

The upper part of the furnace is closed by a plate, a, through which there is an opening, with a hopper, b, affixed, as is shown; C being a valve or slide to be withdrawn when charging the furnace and closed when the charge has been introduced. At dd the furnace is contracted, which is just above the boshes, and below such contraction of the furnace there is an outlet, e, to which a pipe is fixed, and it is at this point the gas (oxide of carbon) passes off from the furnace as generated; and as the gas is liable to carry with it fine dust of the coal and ashes, it may be made to pass through several finely perforated metal or other proper plates, xxx, placed in a vessel, y, at a distance apart, so as to intercept the dust and separate it from the gas. The gas then passes through a suitable pipe, z, and into an ordinary gasometer or suitable receiver, from which the gas is conducted by other pipes to burners, to be used for the purpose of light and heat. f is the blast pipe for introducing a hot blast of air, which I have found does not require to be at a greater pressure than from three to four ounces on the inch. g is a steam pipe by which steam is freely passed into the furnace, taking care that the quantity admitted does



MICHIEL'S GAS GENERATOR, 1846.

not cool the furnace down below a very bright red heat, and the steam so admitted is first heated by passing through suitable heating apparatus in the same way as air is heated for a hot blast, and I prefer that the steam should be raised to 600 degrees of Fahrenheit.

In charging the furnace (after it has been lighted and well heated, as is well understood), if only gas for the purposes of light and heat are intended to be produced, then only anthracite coal or any proper equivalent will be introduced into the furnace and the process will simply consist of keeping up the charge in the furnace as it becomes consumed, and from time to time stopping the admission of the blast and the steam and raking out the ashes at the bottom of the furnace through a suitable opening, which may be covered with an iron plate and closed and luted when the furnace is working off the gas.

By the above described means it will be seen that the gas (oxide of carbon) is obtained by subjecting anthracite coal or other equivalent when in an ignited state to streams of air and steam. I would remark that oxide of carbon is a gas, which is well known, and has before been obtained by different means from those herein described, and its capability of being used as a means of producing light and heat when inflamed is well known, and I mention these circumstances in order to state that I do not claim any novelty in applying such gas to the purposes of light and heat. And I would only further state that when using the gas (oxide of carbon) for the purposes of light, I use it with a portion of carbonated hydrogen to increase its brilliancy. The substance which I prefer for this purpose is oil of turpentine, but other convenient compounds of carbon and hydrogen rich in carbon may be employed.

The end of the pipe by which the oxide of carbon is conveyed from the gasometer or receiver is immersed in the oil of turpentine, and the gas in its passage through such liquid takes up sufficient to give brilliancy to the light, or other modes may be resorted to for causing the gas to become mixed with such substances.

In burning the gas (oxide of carbon) obtained according to this invention for the purpose of heat, I prefer to combine it with atmospheric air, and this I

do by supplying air from another gasometer or receiver, similar to that which contains the gas, so that the air and gas may come to the burner in like quantities and at like pressure and be mixed near the burner, but this using of air is not essentially necessary.

Having thus described the invention and the best means I am acquainted with for performing the same, I would have it understood that what I claim is the hereinbefore explained improvement in the manufacture of gas from anthracite or other equivalent for the purpose of lighting or heating; the same consisting in the employment of a closed furnace (constructed and combined with a gasometer as described) and streams or jets of heated steam and air forced into the charge thereof in a state of combustion, all in the manner as above specified.

I also claim the peculiar manner of increasing the illuminating power of the gas (generated as above) through the agency of oil of turpentine or other equivalent matter, by causing the gas to pass through the oleflant fluid and be impregnated by it essentially as set forth.

MANUFACTURE OF CARBON BISULPHIDE AT ZALATNA, HUNGARY.

By J. FARBAKY.

CAST iron retorts, a (Figs. 1 to 3) of elliptical section, 36 in. by 30 in. and 1½ in. thick are used. They are provided with a jacket of refractory material, in which four 4 in. flues β (Fig. 1) are arranged to insure the uniform heating of the retort. The part γ of the brickwork also consists of refractory material (fire-

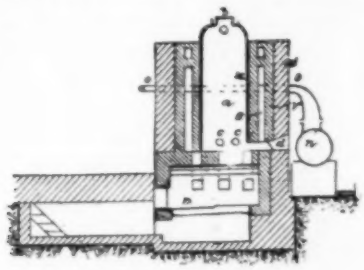


FIG. 1.

bricks), the rest of ordinary bricks δ (Figs. 1 and 3). The openings at b, through which the coal is fed into the retorts, are provided with lids and water joints. The sulphur is added through the openings at c, while the openings, d, serve for the cleaning out of the retorts. The firebars are arranged as shown at r (Fig. 1), the flue gases passing through f into the chimney (Figs. 2 and 3). The iron retorts before being brought into use are lined with a refractory coating by placing within them a jacket of sheet iron of about 2 in. less diameter than that of the retort.

The annular space between jacket and retort is then filled with a warm liquid mixture of the dust of fireproof bricks and treacle. To prevent warping or bending outward of the sheet iron, it is supported by wooden wedges or blocks. The inner space of the jacket is then filled with medium sized pieces of limestone and the retort heated for two or three days. After this time the refractory lining is converted into a hard mass, and the wooden wedges often charred. The lime is then removed without disturbing the iron jacket, which is readily destroyed in the first working of the retorts, when its debris and that of its supports can be removed. Each of these retorts has an average lifetime of eight months, during which it produces about 86 tons of carbon bisulphide. If the retorts are not provided with the refractory lining described, they only last from 1½ to 3 months. (See this Journal, 1889, 118.) When used for the first time the retorts are moderately heated for about 12 days, and are then filled through the opening, b, with pieces of charcoal about 2 in. in diameter.

The heat being now raised, and while fumes appear at the end of the condenser, sulphur is added through short funnel-shaped tubes placed in openings, c (Fig. 1). The sulphur is added in powder or in lumps of about ½ in. diameter. The openings, c, are then closed with clay plugs. For every 90 lb. of charcoal contained in the retorts, 400 lb. of sulphur are added, and this

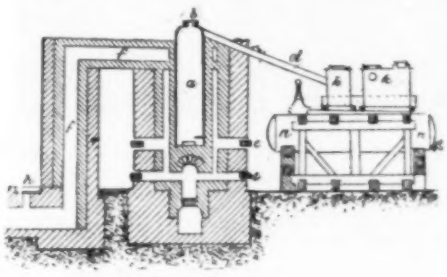


FIG. 2.

weight of sulphur produces from 250 lb. to 300 lb. of crude bisulphide. The charcoal used, before being added, is well dried and ignited. Nevertheless it still contains hydrogen and oxygen, which in the process cause formation of sulphureted hydrogen and other gases. Charcoal made from beechwood is preferable to that made from pinewood, since, owing to its higher specific gravity, the retorts will hold more of it and consequently require fewer charges. This means a considerable saving of time, as two hours before adding fresh charcoal, the feeding of sulphur into the retort is stopped in order to have all the sulphur in the retort converted into bisulphide, and so to prevent losses while the charcoal is being added. The daily working of the retorts is carried on in the following manner: The retorts are filled with charcoal (which takes about five minutes), they are then heated for two hours without adding any sulphur. Next the sulphur is fed in—a process continuing for the next 20 hours. Two hours before adding another charge of charcoal the feeding in of the sulphur is stopped. Throughout these 24 hours the temperature of the retort is maintained evenly at bright redness. Five men attend to two furnaces. At least once every fortnight the retorts are cleared of ashes and coal dust.

During this operation, tube d, connecting the retort and condenser, is closed with a plug to prevent possible explosions. The waste charcoal withdrawn from the retorts is allowed to fall into water to prevent the bisulphide contained therein from evaporating. It is then dried and sieved and used over again. The condensation of the carbon bisulphide takes place in the bell-shaped receivers, k (Figs. 2 and 3), which are arranged in a pan, l, filled with water and acting as a condenser. These receivers, of which four are used for each retort, have a capacity of from 0·32 to 0·384 cubic meter. They are provided with lids of from 30 to 40 cm. diameter, resting in water-lute grooves, which are,

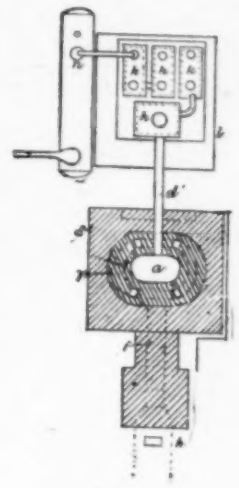


FIG. 3.

however, filled with a mixture of water and fine sand. The bisulphide distills from the retort through the pipe, d, into the condensers, k.

Any vapors not condensed there first pass through the boiler-shaped vessel, n, which is about 9 ft. long and 2 ft. in diameter, and travel then through three U-shaped tubes which are kept cool in a water tank. From these tubes a pipe is carried into the open air, with a downward bend at its end, and a zinc jug is placed underneath it in order to collect any bisulphide which might have escaped. The bisulphide in the morning of each day is drawn from the pan, l, of the condensers and stored in iron tanks. Of the difficulties encountered in this branch of manufacture requiring special mention, the clogging up of the tube, d, by sulphur distilling over with the bisulphide often causes interruption in the working. Experiments with retorts of different shapes and materials showed that distillation of sulphur occurs in the case of every kind of retort. To prevent explosions in attempting to remove distilled sulphur from the pipe, d, or the first condenser during the working of the retort, the pipe, d, is heated from the outside. The molten sulphur then flows into the first condenser and the pan, l, from which it can be removed. To obtain the best results from the charges, the distillation should be conducted throughout at a bright red heat, i. e., about 1,000° C.

The crude bisulphide contains from 6 to 10 per cent. of dissolved sulphur. It possesses a brownish color and penetrating smell. It is purified by distillation from an iron still, y (Fig. 4), 6 ft. high and about the same in diameter. The still is inclosed in a wooden jacket and the space between filled with cinders. The distillation temperature of 48° C. is raised by means of steam injected into the space under the still, forming a false bottom, f', or by an improved process it is passed through f', and the pipe, h, directly into the still, y. The bisulphide vapors pass through x into a system of four U-tube condensers, the distillate being collected under water. z is an opening for filling, as well as for cleaning the still. The still being charged with from 40 to 45 hk. of crude bisulphide, steam at about 8 lb. pressure is admitted into the jacket. Two hours

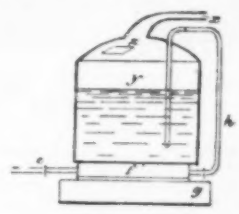


FIG. 4.

afterward the distillation begins, preceded by a hissing noise, due to the rush of sulphureted hydrogen, which is at first evolved. The distillation takes about six hours. The removal of the residual sulphur from the still is a very disagreeable operation, resulting in suffering to the workmen from headache, vomiting, fits of weeping, pains in the limbs, general weakness of body and mind, and especially loss of memory. These affections may develop into actual insanity. To protect the workmen from the bisulphide vapors, the still, y, after the distillation, is filled three-fourths with water, and the latter is heated to boiling by means of directly injected steam, which is admitted through h. After about 20 hours' boiling all bisulphide is driven off and the sulphur is now easily removed from the still. This recovered sulphur is subsequently used again in the manufacture. The bisulphide drawn from the condensers is stored under water in iron tanks holding from 30 to 80 hk. of it. It is sold in iron drums holding 100 or 500 kilos. each. In the former 12, in the latter 2·5 liters of air space are allowed for the expansion of the carbon bisulphide.

THE CHEMICAL PULP PROCESS.

THE following is a description given by Mr. Lauza of the manufacture of paper from wood pulp, as carried on by the Russell Paper Co., at Lawrence, Mass. The kinds of wood used are poplar and spruce. The wood is cut into chips and these are mixed with a liquor which attacks all the ingredients of the wood except the cellulose. This liquor is put, with the chips, into a boiler or digester, into which steam is introduced and in which the mixture is cooked for a suitable length of time. The mixture is then drawn off and washed, and the water and impurities are thrown away, and pure cellulose is left. This, mixed with water, constitutes the pulp. To make a satisfactory product, two different kinds of pulp, sulphite pulp and soda pulp, are used, which are mixed in proper proportions. The sulphite pulp alone would make too harsh a paper, while soda pulp alone would make too weak a paper. The first is used to give strength to the product, and the second softness and delicacy. The sulphite pulp is made by treating the chips with an aqueous solution of sulphite of lime, the chips, liquor and steam being mixed in a spherical boiler which is kept rotating during the cooking. The soda pulp, on the other hand, is made by boiling the chips in a solution of hydrate of soda, and, instead of using a rotating boiler, the chips and the liquor are placed in a vertical cylindrical vessel called a digester. This vessel is provided with a perforated plate near the bottom, and on this plate are placed the chips. The steam is then introduced below the plate, and the liquor is caused to circulate through the chips, during the cooking operation.

In both cases, after the cooking operations are completed the pulp is pumped up to a beating machine, where it is thoroughly mixed, and the fibers are drawn out by causing them to pass between revolving beaters. Here it is also more thoroughly washed than it was after leaving the boilers or digesters.

In the case of the soda pulp it is sometimes bleached in the troughs in which the washing and beating is done.

After the pulp leaves these troughs it is made to pass through a series of very fine screens of metal plates having a series of thin slats. Thence it goes to the wet machine, which is a trough through which a continuous flannel roll is made to pass. The pulp adheres to the flannel and the water drops off. Then the flannel, with its layer of pulp, is squeezed between several sets of rollers, from which the pulp layer emerges as a kind of thick paper, but destitute of consistency. Then, if it has not been previously bleached, it is conveyed on trucks to the bleaching pots. In these it is placed, together with the bleaching liquid, and the whole is stirred by agitators. From here, when the bleaching is finished, the pulp is conducted to a room with a perforated floor, where it is washed by a stream of water from a hose, leaving the bleached pulp on the top of the false floor.

Next follows the mixing operation. In the trough of the mixing machine are placed the sulphite and soda pulp in the desired proportions, together with any other ingredients that may be desired, such as clay, to make the paper take ink, sizing, resin soap, etc. By suitable machinery the materials are caused to travel round and round in this tank until they are thoroughly mixed. For the fine papers a Jordan engine is used instead.

After this the pulp is ready for the paper machine proper, which may be a Fourdrinier or a cylinder machine. In either case the pulp is caused to adhere to a layer of cotton or wool, which forms as it were an endless belt, the water dropping off, and the pulp being carried along on this cloth, gradually passes between pairs of rolls, the first pair usually making the water mark. The pulp then reaches the calender rolls, inside of which steam circulates. Here the pulp is dried, and, as it were, ironed, and receives a gloss. It is then rolled and subsequently cut into sheets of any desired size.

The foregoing is a very brief description of the principal steps only. The following important details have still to be mentioned:

(1) When the wood is received at the mill the bark and any other roughness are removed by a special machine, made somewhat on the principle of a milling machine. Any large knots are then drilled out, a machine being also provided for this purpose. The log is then placed in a machine containing a set of revolving knives which chips off the wood obliquely to the grain. From this machine the chips are carried by belt carriers to the upper part of the building, where they are led to hoppers over the boilers or digesters respectively.

(2) The sulphite of lime solution is made as follows: On an upper floor are three closed tanks, arranged on three different levels, and so connected that a liquid in the upper one, when it reaches a given level, will overflow into the second one, and in like manner from the second into the third. When it reaches a given level in the lowest tank it overflows into an open tank placed at a still lower level, and directly over the boilers. Above the system of three closed tanks is another open tank containing lime water, which flows continuously from this tank downward through the entire system. In the basement is a furnace for burning sulphur, and thus forming sulphur dioxide, and the passage through which this gas escapes from the furnace leads into the lowest of the system of three tanks, then into the next and then into the upper one, from which it is pumped out by a vacuum pump, which draws the sulphur dioxide and the accompanying nitrogen through the solution in the three closed tanks. The sulphite of lime thus formed overflows into the lowest open tank, from which it is delivered by means of a hose to the boilers.

(3) The hydrate of soda is made by boiling soda ash and lime water by means of a current of steam passing through a coil of perforated pipes within the boiler. The hydrate of soda is drawn off, and the carbonate of lime is thrown away.

(4) The material washed out from the pulp in the

soda process is, of course, very dilute, but it is nevertheless desirable to reclaim and to re-employ the soda. For this purpose the liquid is reduced in a Yaryan or other suitable evaporator to the consistency of molasses, after which it is placed in a revolving drum, open at both ends, one end communicating with a furnace and the other with the chimney. The inside of this revolving drum is conical. The material is thus burned, and comes out as a black ash, consisting of soda ash, carbon and a little sand. This black ash is leached with water, which dissolves out the soda ash, leaving behind the other ingredients, and we thus have again a solution of soda ash from which to make the liquor.

AMATEUR CHRONOPHOTOGRAPHY.

Chronophotography has hitherto always been considered as a science of which the practice is limited to a few rare specialists who devote themselves to the study of motion, and, chiefly, to the analysis of the

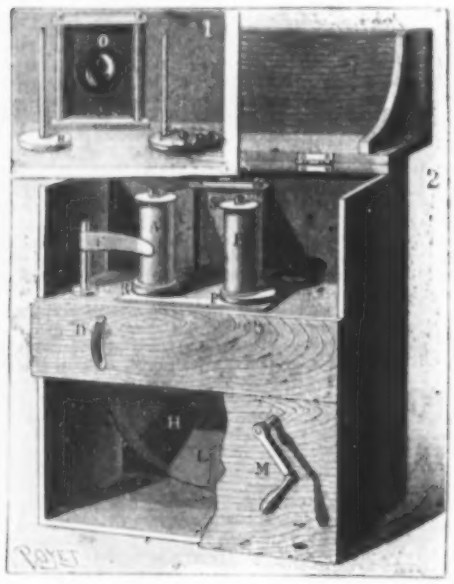


Fig. 1.—AMATEUR'S CHRONOPHOTOGRAPHIC APPARATUS.

walk of man and animals or to the flight of birds and insects.

The fact is that apparatus have not been within the reach of every one, because of the complication of their mechanism, and consequently their high price. Our readers have been enabled to judge of some of these instruments through the description of them given in these pages. We shall remind them briefly that there are three different types in use, in two of which a single objective with a disk shutter revolving at great speed is employed. In one, the object shifts and gives several images upon an immovable plate, while in the other the object is stationary and the movable sensitized surface gives well separated images. The third method, which is the least interesting, consists in taking as many objectives and plates as it is

Fig. 2.—METHOD OF USING THE DEMENY APPARATUS.

desired to have images and in freeing the shutters of each objective one after the other. The most elegant solution of the problem, the only one that is really practical, is that which permits of obtaining, upon a band of film, and with a single objective, a succession of well separated images whose number depends only upon the length of the band employed. It is the method that has been utilized for several years by Mr. Marey at the physical laboratory of the Bois de Boulogne. It is the one, too, that has been adopted by Edison for his famous kinetograph, which has already been much spoken of and the results of which can now be seen at Paris in the apparatus that is being exhibited to the public in the hall of dispatches of the Petit Parisien.

The difficulty in this case consists in arresting the sensitized band for the very brief instant in which each image impresses the plate, and this is what up to the present has necessitated considerable of a complication.

Mr. George Demeny has just devised a most simple arrangement that, so to speak, suppresses all mechanisms and permits of having an eminently portable and, at the same time, cheap apparatus, as may be seen from the following description.

A wooden box, having about the dimensions of an ordinary 7 by 9 inch apparatus, is provided with an objective of wide aperture (a portrait objective, for example), of which only the center is utilized. Back of this objective and as near as possible to the sensitized surface, the disk shutter is revolved by means of a winch. Up to this point, there is really nothing new; the principal improvement consists in the unwinding and arrest of the sensitized film. Fig. 1 (No. 1) represents the principle of the system. Two disks, R and P, are each mounted upon an axis passing through their center. The bobbins that carry the film are fixed, one of them at R upon a spindle mounted in the axis of rotation of the disk and the other at P upon a spindle mounted eccentrically to such axis. It is this eccentric position that chiefly constitutes the invention. Let us, in fact, suppose the two bobbins in place (Fig. 1, No. 2), the film wound upon A having one of its extremities attached at B, in following the course, C S, during which it is passing behind the objective. The two bobbins cannot have any proper motion, in consequence of the method of fixing adopted. They and the disks, R and P, that support them become interdependent. If we cause the disk, P, to revolve, the film coming from A will wind around B; but, in consequence of the eccentric position of this bobbin upon the disk, traction will cease to occur for a very brief instant, at the moment at which the bobbin, B, approaches A as closely as possible. Despite this, as the winding always proceeds to a degree proportional to the unwinding, the film remains perfectly taut. It is precisely at this moment that the window, H, of the disk, L, uncovers the objective.

It will be readily understood that the winch, M, sets the disk in motion, and it is this which, through a gearing, controls the operation of the bobbins. There is therefore always an exact mathematical coincidence between the arrest of the film and the passage of the window, and this is essential for the sharpness of the image. This would not always occur if we depended upon a friction device for the arrest of the film, for in this case a sliding might occur that would produce a blurring of the image.

The solution offered by Mr. Demeny is therefore the most simple and, at the same time, the surest one. The simplification of the mechanism has permitted of constructing an apparatus light enough to allow of operating without a foot, by holding it simply in the arm (Fig. 2). In order to give a complete idea of the system, let us add that a special arrangement permits of opening the objective and starting the bobbins only at the desired moment, after the disk shutter has been set in motion, and of taking either a single image or a series of three or four, say a complete series of twenty-four or more, according to the length of the film employed. Each film terminates in a strip of black paper which is glued to it and forms a complete covering after the winding upon the bobbin. This arrangement, which completely protects the sensitized part from the light, permits of changing the bobbins in broad daylight. Twenty of them can be stored in

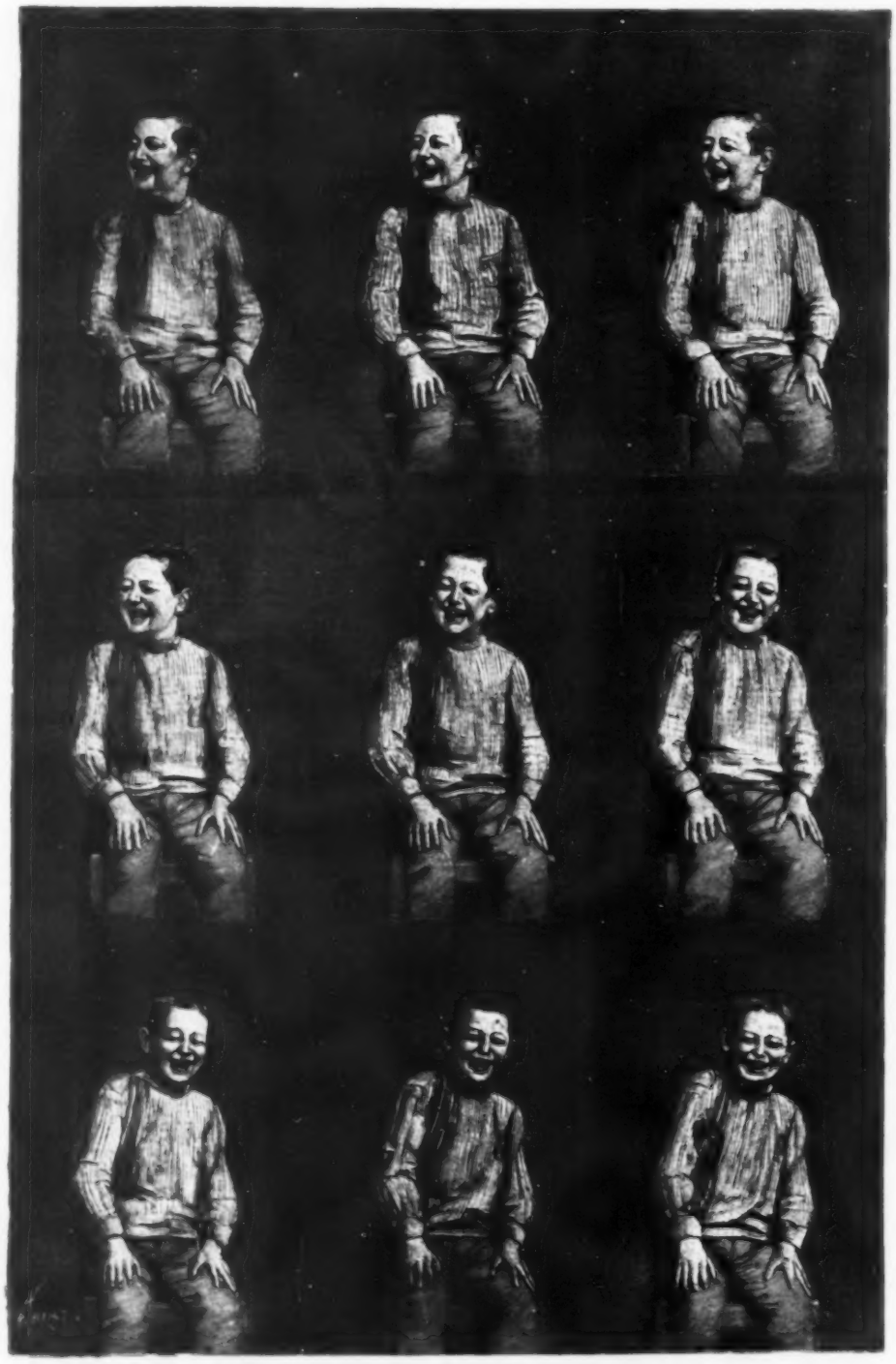


Fig. 3.—FACSIMILE, ACTUAL SIZE, OF A PORTION OF A SERIES OF INSTANTANEOUS PHOTOGRAPHS TAKEN WITH THE DEMENY APPARATUS.

those parts of the box in which space is left by the mechanism, so that one has thus always a large supply on hand.

Here, then, we have chronophotography placed within the reach of all. The apparatus in the hands of amateurs will entirely change the conditions under which studies of this kind have hitherto been made, by permitting every one to extend the field thereof to the most varied subjects.

It will thus, we trust, modify the practice of instantaneous photography so often criticised, and sometimes justly, since the sole attitude that a single image gives does not always agree with what the eye perceives. The impression that the motion leaves with us is often quite different from what is given by a single instantaneous negative, and the sensation of reality is afforded us if we find ourselves in the presence of a series of images in which each is explained by the one that precedes and the one that follows. The well known labors of Messrs. Muybridge, Marey and Anchutz are in evidence, moreover, to prove what we say, and we have no need to dwell thereupon.

But it is in the portrait especially that we should

like to see a complete transformation effected, and we rely upon the amateur to form the public taste in this regard and to force the professional photographer to abandon the conventional posing. When we regard the products of these artists (and how few merit the name), we find in most cases a facial expression that is in nowise that with which we are familiar in the subject and which rather expresses a feeling of annoyance. How could it be otherwise with the usual method of operating? The model is tortured for half an hour, and then he is told to remain perfectly immovable and to assume a pleasant expression! Unless they are consummate dramatic artists, how many persons are there who could do this under such circumstances? What a difference, on the contrary, when we have a series such as that represented in Fig. 3. The child is taken here on the instant. Add a little color and cause the images to revolve in a zootrope, and you will see him alive. These negatives, which are reproduced in actual size, were obtained by Mr. Demeny with his new apparatus. It is the outcome of his studies upon the play of the physiognomy. It will be remembered that he began two years ago with the photography of speech, but he was then obliged to place himself in full sunlight, and although the negatives obtained were interesting, and even complete from the view point of the special details that it was a question of obtaining, they were not very artistic. Now it is possible to operate in the shade and even in the studio. It merely remains to take the habitude and no longer to make one's subject pose, but to make him speak and to seize him with the usual expression that is characteristic of him, and which, let it not be forgotten, is a series of expressions.—La Nature.

OLD "SWEDE'S CHURCH," WILMINGTON, DELAWARE—NORTHWEST VIEW.—From a sketch by Mr. E. Eldon Deane.

HOLY TRINITY CHURCH, WILMINGTON, DEL.

THIS picturesque church (formerly Holy Trinity, Christina, Pennsylvania) was erected by the Swedish Lutherans and set apart for sacred use in the year 1699. It is recorded that at the time of its erection such of the people as were too poor to contribute to the building fund lent their physical energies to the work, the women carrying the mortar in their aprons. Rev. Eric Bjork, its first minister, was recalled to Sweden in 1714 by order of Charles XII., and appointed pastor of the church in the mining town of Fahlun and provost of the district. We may surmise it was by his interest that the mining company of Fahlun presented in 1718 the handsome church plate comprising chalice, paten and pyx, which are still in use, though after the Anglican ritual. This, and the Gloria Dei church in Philadelphia, are two of the old Swedes' churches that, after the revolution, came under the control of the Episcopal denomination.—The Builder.

OLD "SWEDE'S CHURCH," WILMINGTON, DELAWARE SOUTHWEST VIEW.—From a sketch by Mr. E. Eldon Deane.

THEATER FIRE CATASTROPHES AND THEIR PREVENTION.

By WM. PAUL GERHARD, C.E.

I.

THE prevention of fire and incidental panic in halls of audience requires that in the planning, construction, interior arrangement and equipment of such buildings certain rules are followed and certain precautions are observed by the architects and engineers of such structures. Of the greatest importance in respect to the enactment of strict building laws are all buildings where a multitude of people are congregated, by day or at night, for worship, education or amusement, such as churches and synagogues, schools and colleges, concert and lecture halls, circuses and theaters. I shall restrict my remarks to theaters, although much of what I shall say applies equally to the other classes of buildings named.

The prevention of theater fire calamities is a subject in which not only firemen but the general public are, or ought to be, much interested.

In the planning and construction of theater buildings, even more than in other buildings, the combined skill, knowledge and talent of both the architect and the engineer are necessary to create a model and safe structure. While the architect works out the best plan on the available site, determines the general arrangement of the divisions of the building, decides the mode of construction, designs the elevation, and selects the decorative treatment of the interior, he is assisted by the engineer or by specialists in the various engineering branches in the solution of intricate problems requiring special expert knowledge, such as the construction of difficult foundations, the calculation and the working out of details of all iron constructions, the design of the mechanical or power plant, comprising steam boilers, engines, dynamos, hoisting and general stage machinery, the heating and ventilation of the building, the gas lighting and the electric lighting system, the plumbing, drainage and water supply, the arrangement of the toilet rooms, the general sanitation, and finally the fire protection of the theater.

THEATER FIRE STATISTICS.

To begin with, I shall give a few statistics regarding theater fires and their causes. Here we at once encounter much difficulty in gathering and presenting accurate and reliable figures and facts.

There are numerous cases in which a fire breaking out in a theater, on the stage, in the auditorium or elsewhere, is at once extinguished by the stage hands or by the firemen on duty in the building. Many cases of this kind never become known to the public or to the press, and no accurate record is kept of them. In other instances, again, blind fire alarms are followed by a panic and often by loss of life. When a fire in a theater breaks out during the night and destroys the building, the cause of the same often forever afterward remains a mystery. Distinction must be made between occasional outbreaks of fire which are subdued before they can spread and such fires which completely destroy the building. The data given below refer only to theaters which are entirely burned down.

Those fires which break out during a performance, when the building is crowded with people, are naturally the ones of greatest interest to us. If accompanied, as they unfortunately often are, with loss of life, the number of persons killed and wounded is difficult to ascertain with absolute accuracy, as many perish in the building who are not missed by friends or relatives. The tendency in these cases is usually for the press to exaggerate the number of victims, whereas, on the other hand, the theater officials or the municipality often try to keep the figures below the actual number. The curious mistake is sometimes made of counting both the dead and the wounded in the same figure of victims, obtaining thereby largely increased and incorrect figures.

We are principally indebted for theater fire statistics to the works of Herr August Foelsch, a German civil engineer, recently deceased; of Herr Franz Gilardone, a retired German fireman; of Capt. Shaw, of the London Fire Brigade; to Dr. Choquet, physician to a French Life Insurance Company, and to the labors and reports of John C. Hexamer, Esq., a civil engineer and insurance surveyor, of Philadelphia. Their figures and statistics do not, by any means, agree, and it is difficult to account for the discrepancies. Taking the work of Herr Foelsch as, on the whole, the most complete and reliable guide, although it is not brought quite up to date, being published in 1878, with a supplement issued shortly after the Vienna Ring Theater fire in 1882, we find a list of 516 theaters enumerated, which up to and including the year 1877, were completely destroyed by fire.*

Out of these, 460 theaters were burnt in 100 years. His list contains of theaters in the principal cities, the following:

London	31	Cincinnati	9
Paris	29	New Orleans	8
New York†	26	Bordeaux	7
San Francisco	21	Venice	6
Philadelphia	17	Baltimore	6
Boston	11	Cologne	5
Glasgow	11	Edinburgh	4

Among the 516 theaters we find 37 theaters which were burnt twice; 8 theaters, which were burnt three times; 4 theaters, which were burnt four times; 1 theater (the Bowery Theater, in New York), which was burnt five times; also, one theater in Spain, which burnt down seven times.

Regarding the average life of theaters, the records are confined to 252 theaters, and show that

Theaters.		
5	burnt down	before the opening.
70	"	in the first five years after opening.
38	"	between 6–10 "
45	"	" 11–20 "
27	"	" 21–30 "
12	"	" 31–40 "
20	"	" 41–50 "
17	"	" 51–60 "
7	"	" 61–80 "
8	"	" 81–100 "
3	"	after over 100 years' existence.
252		

Out of a total of 252 theaters, 70, or more than one-fourth of them, are destroyed before they reach an age of five years.

Theaters, therefore, as a rule, do not attain an old aged, and Herr Foelsch figures the average age of these 252 theaters as 22¾ years. For the United States, the average life of a theater is said to be only from 11–13 years, but it should be remarked that these figures were reached some years ago, before the more strict theater laws of some of our large cities (New York and Boston, and quite recently Brooklyn and Philadelphia) were enacted.

Recent analytical studies of the question have elicited the fact that there are two periods in the life of theater buildings when they are most endangered or subject to destruction by fire, namely, one from the time of the construction up to and including the first five years; and the second period, after the theater has been opened from 40–50 years. This may be explained first, by the fact that in a new theater the safety appliances, the arrangements for lighting, the scene hoisting devices, the fire protection appliances, are rarely in perfect working order, and the theater employes have not, as yet, become accustomed to handling them, and are likewise unfamiliar with the rules of management.

The second period of renewed danger is explained by the fact that, after the number of years quoted above, much of the apparatus in a theater has become worn out or useless, and is not always kept in repair or replaced by new apparatus, and it may also be attributed to the fact that after the lapse of many years, the theater management and inspection are apt to be less strict, and that often interior alterations are made which unfavorably affect the safety of the building.

From the middle of the last century to our present day, nineteen theaters on the average have been destroyed annually by fire. For those who are interested in more detailed figures, I quote the statistics gathered by Herr Foelsch and by Dr. Choquet, the latter's figures being placed in brackets.

				In all countries.
In the years	1751–1760	there were	4	theater fires.
"	1761–1770	"	8	"
"	1771–1870	"	9 [11]	"
"	1781–1790	"	11 [13]	"
"	1791–1800	"	13 [15]	"
"	1801–1810	"	17	"

* This figure, in the supplemental edition of 1882 to the work, was corrected to 523.

† Since 1821 up to the present day 29 theaters have burnt down in New York City.

In the years	1811–1820	there were	16	[18]	theater fires
"	1821–1830	"	30	[32]	"
"	1831–1840	"	25	[30]	"
"	1841–1850	"	43	[54]	"
"	1851–1860	"	69	[76]	"
"	1861–1870	"	99	[103]	"
"	1871–1880	"	181	[169]	"
"	1880–1885	"	—	[174]	"

Taking each year from 1871, we have the following numbers

In 1871 there were		20	theaters destroyed.
1872	"	13	"
1873	"	15	"
1874	"	15	"
1875	"	14	"
1876	"	19	"
1877	"	17	"
1878	"	20	"
1879	"	25	"
1880	"	23	"
1881	"	28	"
1882	"	25 [37]	"
1883	"	22	"
1884	"	9 [40]	"
1885	"	9	"
1886	"	7 [8]	"
1887	"	12 [18]	"
1888	"	15	[up to November.]

The fire loss represented by these figures reaches many millions of dollars' worth of property.

The hour of the day in which theater fires started is of considerable interest. Out of 289 fires, 56 theaters burned during the day between 7 A. M. and the afternoon, or 19·4 per cent.; 15 theaters burned one hour before beginning of performance, or 5·2 per cent.; 36 theaters burned during performance, or 12·4 per cent.; 69 theaters burned within two hours after close of performance, or 23·9 per cent.; 113 theaters burned during the night and before 7 A. M. next morning, or 39·1 per cent.

Later on, when the records of 373 theater fires were available, Herr Foelsch found this percentage to remain nearly the same, viz.: 19·9, 5·6, 11·6, 22·6, and 40·3 per cent. respectively. It will be seen from these figures that the greatest danger from fire to a theater is during the two hours following a performance, and not during the performance, as would naturally be supposed. The reason for this is partly that, during the performance, a greater watchfulness exists as regards open lights, the sources of heat, and the other usual causes of fire, and partly because many fires, while actually started during a performance, for instance, by carelessness in the use of fireworks or by the use of firearms, do not break out at once, but smoulder for a while in the inflammable scenery and woodwork of the stage, and break out during the hours following the performance. The risk from fire immediately before the performance and while the audience is admitted is found to be three times as great as during other hours of the day, which is explained by the fact that at this time the gas flames are lit which illuminate the scenery.

Theaters are, therefore safest in the day time, the danger is increased threefold during preparations before the performance, because of lighting up, etc., it is reduced during the performance on account of the careful inspection and greater watchfulness on the stage, but is still twice as large as during the day. The danger reaches a maximum (seven times the day risk) during the two hours after the close of the performance, and it remains during the night nearly three and a half times as great as during the day. (Sparks from fireworks or pistol wads may remain glowing for hours after the performance.)

The theater fires which break out during the performance are often accompanied with loss of life of both spectators and actors, and are therefore of particular, though sad interest to us. The life of firemen is often greatly endangered at theater fires at all hours, and the list of instances where firemen have been killed while engaged in their duty in trying to save burning theaters is quite large.

Herr Foelsch describes in detail 36 theater fires between 1770 and 1877, which began during the performance, and out of this number not less than six were accompanied by appalling loss of life. From 1877 to 1889 six other deplorable theater calamities have occurred. In the 12 years from 1876 to 1888, not less than 1,600 people have been killed in the six well known theater disasters of Brooklyn, Nice, Vienna, Paris, Exeter, and Oporto, nearly all of the victims being dead within ten minutes from the time when the flames and the smoke from the stage reached the auditorium and the galleries.

Dr. Choquet, in his statistics, enumerates a total of 732 theaters destroyed by fire from 1751 to 1885, with a total number of victims, i. e., both killed and wounded, of 6,573. This list includes fires where firemen lost their lives in the performance of their duty. Since the beginning of this century 536 theater fires occurred, and from 4,500 to 5,000 persons had been killed or wounded.

Here are in detail, in periods of ten years, some of the figures of victims of theater fire calamities given by Dr. Choquet:

In the years—		
1751–1760	10 victims.	
1761–1770	4 "	
1771–1780	154 "	[Amsterdam, 25 d. 1772 Saragossa, 77 d. 1778 52 w.]
1781–1790	21 victims	
1791–1800	[1010 v., Capo d'Istria, 1794, 1000 v.]	
1801–1810	37 v.	
1811–1820	85 v.	[Richmond, 1811, 72 v.]
1821–1830	195 v.	[Phila., 1829, 97 v.]
1831–1840	813 v.	[St. Petersburg, 1836, 800 v.]
1841–1850	2114 v.	[Canton, 1845, 1,670 v.] [Carlsruhe, 1847 63 d., 203 w.] [Quebec, 1846, 200 v.]
1851–1860	241 v.	[Livorno, 1857, 43 d., 134 w.]
1861–1870	104 v.	
1871–1880	1217 v.	[Ahmednuggur, 1878, 40 v.] [Brooklyn, 1876, 283 v.] [Shanghai, 1871, 120 v.] [Sacramento, 1876, 110 v.]
1881–1885	628 v.	[Nice, 1881, 70 v.] [Richmond, 1885, 100 v.] [Vienna, 1881, 450 v.]
1887, Paris,	150 v.	
1888, Oporto,	140 v.	
1887, Exeter,	300 v.	
1892, Phila., Central Theater.		

Before proceeding to study the causes of theater fires, I will give a brief list of 12 prominent theater calamities of this century, the horrors of many of which are probably not yet forgotten.

LIST OF TWELVE PROMINENT THEATER FIRE CALAMITIES OF THIS CENTURY.

1. Theater in Richmond, Va.
   Date: December 26, 1811. Time of fire: during the last act of the evening performance. Number of people in audience: about 600. Cause of fire: careless hoisting of a stage chandelier with lighted candles, whereby a border became ignited. Panic, jam at exits. Number of victims: 70 persons killed, many injured. No data available as to location, plan, construction and equipment.
2. Lehmann Theater and Circus at St. Petersburg, Russia.
   Date: February 14, 1836. Time of fire: during the afternoon performance, at 4 o'clock. Number of people in audience: unknown. Cause of fire: a stage lamp, hung too high, ignited the stage roof. Panic, jam at exits. Number of victims: about 800 persons killed. Location in an open square. Construction: temporary wooden structure. Exits obstructed by the panic-stricken crowd.
3. Royal Theater at Quebec, Canada.
   Date: June 12, 1846. Time of fire, not stated. Number of people in audience, unknown. Cause of fire: the upsetting of a lamp on the stage ignited a wing. Number of persons killed: about 100. Construction, of combustible material. Chief defects: insufficient exits, narrow stairs; one wooden staircase broke from overweight of the crowd, and thereby obstructed one of the exit doors.
4. Grand Ducal Theater at Carlsruhe, Baden, Germany.
   Date: February 28, 1847. Time of fire: just before beginning of evening performance. Number of people in audience: about 2,000. Cause of fire: the careless lighting up of the gas lights in the Grand Ducal box ignited the draperies. Number of victims: 63 persons dead and 200 injured. Location: entirely free on open square. Construction: wooden interior, the four exits ordinarily effected the emptying of the house in six minutes. Chief defects: the main entrance to the theater was bricked up (!). Of the four exits mentioned, only one was open; the other three were locked and barricaded. The gas was turned off in the street after the fire broke out, but the oil lamps in corridors were kept burning. The occupants of the parquet and of the balconies escaped. Most of the victims were gallery spectators, who became suffocated by smoke. Many were saved by breaking in the locked exit doors.
5. Teatro degli Aquidotti, Leghorn, Italy.
   Date: June 7, 1857. Time of fire: about 8 o'clock in the evening. Number of people in the audience: about 3,000. Cause of fire: a rocket, part of fireworks on the stage, ignited the scenic decorations. Number of victims from 43 to 100 killed and 134 to 200 injured. No details.
6. Conway's Theater, Brooklyn, N. Y.
   Date: December 5, 1876. Time of fire: during the last act of the performance of "The Two Orphans." Number of people in audience: about 1,000, viz.: 250 in parquet, 350 in balcony, 405 in the gallery. Cause of fire: a border caught fire from the border lights, perhaps owing to a sudden draught, caused by opening a window. The fire was increased by the opening of a large door at the back of the stage. Number of persons killed: 283; all from the upper gallery. Location: building stood detached on three sides. Construction: ordinary, but with well arranged exits, permitting the emptying of the theater in from five to six minutes. Plan of theater: considered comparatively good at the time. Chief defects: no fireproof curtain, no water available for fire purposes. No fire hose at the fire hydrants, nor any other fire extinguishing appliances available. Auxiliary exit doors for the gallery kept closed. Only one staircase for the gallery. Stage overcrowded with scenery. Loft over the auditorium filled with much inflammable scenic material. Proscenium of wood. During fire gas was turned off in the street.
7. Municipal Theater, at Nice, Italy.
   Date: March 23, 1881. Time of fire: at 8:30 in the evening, immediately before the beginning of the performance. Number of people in audience: not known. Cause of fire: in lighting the border lights an explosion of gas took place, igniting at once the scenic decorations. Number of persons killed: from 150 to 200; nearly all from the upper gallery. Location: in an open square. Construction: substantial. Plan and arrangement: fairly good. Chief defects: no fireproof curtain, no oil lamps in corridors and exits. Auxiliary exit door from gallery to the safety stairs could not be found on account of darkness, the gas lights having been extinguished. The lower part of gallery stairs steep and with winding steps. The exit doors obstructed by the jam.
8. Ring Theater, at Vienna, Austria.
   Date: December 8, 1881. Time of fire: about 6:45 in the evening just before the beginning of the performance. Number of people in the audience: about 1,800. Cause of fire: the careless lighting of the border lights by means of an alcohol torch (the usual electric flashlight apparatus being out of order) ignited a hanging border. Number of persons killed: at least 450, many from the upper gallery. Location: standing free on three sides. Construction: substantial, but stairways bad. Plan and arrangement: defective. Chief defects: iron fireproof curtain could only be lowered from the rigging loft, and could not be lowered at the time of the fire. Special exit doors locked, keys and locks rusty. Gas lights extinguished; oil lamps provided in corridors, but not lighted. The exits insufficient, and obstructed by the jam. This fire was very similar to the Brooklyn Theater fire. The fire caught in each case among the flies from a border light. The bursting open of a large door in rear of stage let in a blast of air, which drove the flames and the suffocating fire smoke through the proscenium opening into the auditorium.
9. Circus Ferroni, at Berditscheff, in Russian Poland.
   Date: January 13, 1883. Time of fire: during evening performance. Number of people in the audience: about 600. Cause of fire: a stableman working in the stable adjoining the circus was smoking a cigarette, and was lying on straw, which ignited; a fellow laborer ran for a pail of water and left a door open, which created a strong draught, and thus fed the flames. Inside of twenty minutes the whole circus stood in flames. Number of victims: official figure, 268 persons burned to death; other reports state 430 dead, 80 mortally injured, 100 persons missing. Many children crushed and suffocated in the jam of people. Both stable laborers who caused the fire burned to death; twenty-seven horses and eleven trained dogs burned. Construction of building: of double walls of wood, with an interior filling of straw (!) between the boards, as a protection against the cold. No safety measures against fire. One safety exit, but not known to the public. Owing to the extremely cold weather, there was scarcity of water, and a fire engine, in running to the fire, was delayed by breaking through the ice.
10. Opera Comique Theater, Paris, France.
    Date: May 25, 1887. Time of fire: about 9 P. M. Number of people in audience: about 1,600. Cause of fire: scenery ignited from the gas lights. Number of persons killed: from 70 to 110, largely from the upper gallery and stage people. Location: standing free on three sides. Construction: good, although not fire resisting. Plan and arrangement: faulty. Chief defects: exits for about half the stage people over a narrow wooden bridge over upper part of stage. Iron curtain not lowered; fire hydrants not used; gas extinguished in the exits and corridors.
11. Exeter Theater, Exeter, England.
    Date: September 5, 1887. Time of fire: during evening performance. Number of people in audience: not stated. Cause of fire: scenery caught fire from the gas lights. Number of persons killed: from 166 to 200, mostly from the upper gallery. Location: in an open square. Construction: bad. Plan and arrangement: fairly good, but the upper gallery had only one exit, which was badly arranged and obstructed. Chief defects: no fire curtain; insufficient fire appliances on stage; stage overloaded with scenery; insufficient and badly arranged exits.
12. Theater at Oporto, Portugal.
    Date: March 31, 1888. Cause of fire: a rope in the rigging loft came too near the border lights and caught fire, which quickly spread. A panic broke out, and the safety exits being closed, a jam resulted in the corridors. Many persons jumped to the street from the windows, others followed on top of those lying wounded and killed in the street. Sailors and marine soldiers in the upper gallery are said to have used their knives to kill persons standing in their way. Number of victims: 240 persons. Chief defects: theater built entirely of wood; all stage gas lights were open and unprotected lights. No safety appliances of any kind.

It may be noted that in nearly all the catastrophes briefly described fire broke out high up in the inflammable scenery, near the borders, and was caused by gas lights coming into contact with the combustible scenery.

Besides the twelve theater fires briefly mentioned, in which alone about 3,000 persons lost their lives, there is a large list of other fires, full of horrors, about which, however, the details are meager.

Among these I mention the fire in a theater at Canton, China, on May 25, 1845, where 1,670 persons are said to have perished; the fire of the theater at Whampoa, China, in 1853, caused by fireworks, and killing thirty persons; the theater at Tientsin, China, burnt in May, 1872, with 600 persons dead; the fire at a theater in Ahmednuggur, East India, on May 11, 1878, when forty persons were killed; the fire of the Gayety Theater in Milwaukee, on November 15, 1869, caused by the upsetting of a kerosene lamp on the stage, whereby two persons were burned to death, and about thirty injured; the fire in a theater at Tschernigow, Russia, on December 24, 1882, caused by a gas meter explosion, and resulting in a panic, wherein several people were killed and 100 injured; the theater fire at Dervio, Como, Italy, on June 25, 1883, where forty-seven persons lost their lives, and the fire at the Central Theater, in Philadelphia, Pa., in 1892, causing the death of several persons.

Again, there are numerous instances of large loss of life during panics in public halls and places of assembly, of which I will mention only the panic at the Victoria Hall, in Sunderland, England, where of 2,000 children present, 183 were crushed and trampled to death, and the panic in a circus at Richmond (State?) in 1885, whereby 100 persons were killed.

CAUSES OF THEATER FIRES.

Before discussing the precautions necessary for prevention, let us inquire briefly into the chief causes of theater fires and calamities. This study of the causes leading to fires and panics is of the utmost importance, because it enables us to derive therefrom the best practical lessons as to what to do, and what to avoid, to prevent the occurrence of a disaster.

Dr. Choquet, in discussing the causes of theater fires, divides them into two principal groups, viz.: (1) The intentional causes, or incendiarism; and (2) the accidental causes.

Leaving incendiarism, from malice or other reason,

out of consideration, we can distinguish further between:

1. Exterior causes, such as lightning, exposure, dangerous trades carried on in the vicinity of a theater, bombardment of the city, or riots.

2. Interior causes, viz.: a, on the stage; b, in the auditorium; c, in other parts of the house.

3. Mixed causes, such as fires originating in living apartments or in stores, or offices, or restaurants, under the same roof with the theater proper.

Placed in the order of their frequency, we find theater fires to have their origin:

1. On the stage.

2. In the actors' dressing rooms, in the engine and boiler room, in the cellar, and in the administrative offices.

3. In stores, offices, living apartments, or restaurant kitchens in the theater.

4. In the auditorium.

5. In outside causes; such as exposure to neighboring buildings on fire.

In not a few cases the exact cause of a theater fire remains forever unknown. This is due largely to the rapidity with which the flames spread among the vast mass of combustible material, and to the haste and confusion incident to the fire, particularly when this breaks out during the night time. The best information about causes of theater fires is derived from those fires which break out during a performance, and which, for obvious reasons, are the most dangerous and often lead to deplorable calamities.

The majority of fires during performances break out on the stage, and are due to open and unprotected or to deficiently protected lights in too close proximity to or amid a mass of unprotected and highly inflammable scenery, draperies, gauze, ropes, and woodwork. Among the numerous other causes I mention the careless lighting of gas lights on the stage, by alcohol lamps on long poles, and sometimes defects in the electric spark or flashlight apparatus, causing escapes of gas or gas explosions; carelessness in the use of lamps on the stage or in the dressing rooms, or exposure of lamps to sudden draughts; careless handling of candle lights in dressing rooms; alcohol lamps used by actresses for heating hair curling irons in the dressing rooms; the dropping of sparks from the lighting torches on the stage, or on decorations or papers; temporary gas conduits needed on the stage, generally consisting of rubber tubing, becoming leaky, or not being well jointed together, or becoming otherwise damaged and defective; the use of portable open gas burners near movable scenery; the use of defective gas burners and gas fittings, exposed gas pipes damaged by the shifting or carrying about of heavy pieces of scenery or furniture; main gas pipes becoming leaky, and causing escapes of gas; gas explosions in the gas meter vault, or elsewhere; swinging gas brackets setting woodwork or scenery or curtains on fire. Lights other than gas lights are often worse; the upsetting of coal oil or kerosene lamps, and the explosion of such lamps, are fruitful causes of fire.

The electric light, finally, although the safest comparatively of all lights, may cause fire by reason of electric light wires not being properly insulated, or being faultily installed.

The careless use of matches, other than safety matches, throwing away of lighted matches, and rats or mice gnawing phosphorus matches, in hidden recesses, are among the causes of fires.

The smoking of tobacco, cigars, cigarettes as well as pipes, and the careless throwing away of lighted cigars or cigarettes, in dressing rooms or on the stage, or in the sub-basement; the careless use of the oxy-hydrogen or lime light; the use of fireworks in spectacular plays calculated to attract the public; the use of red fires, torches, Roman candles, the firing of rockets, are dangerous causes of fire, because a spark often lodges amid scenery and the flames break out during the night following the performance. Sometimes fireworks are prepared for the play in the theater building, which is a pernicious practice. The representation of fire or conflagrations or actual explosions in the course of the play, the firing of firearms, pistols or guns, with paper wads; the careless handling and use of benzine or turpentine in workshops and costume rooms. The heating apparatus, particularly stoves and furnaces when overheated during extreme cold weather, defective flues, timber near woodwork; floor registers and heat flues; hot ashes; the use of straw or hay on the stage; the careless use of soldering furnaces on tin theater roofs; gauze dresses of ballet dancers catching fire and in turn setting decorations on fire; non-removal of rubbish and trade refuse; and accumulation of large masses of combustible material, woodwork, canvas, gauze, pasteboard, hemp ropes, paper with varnish, so-called properties, etc., on the stage; the use of rooms in the theater, in the basement or in the loft over the auditorium, or even of the stage, as paint or carpenter's shop; the spontaneous combustion of heaps of waste material of oily rags used for cleaning lamps or in engine or dynamo room; the action of rays of the sun concentrated by window glass or lenses; carelessness in the necessary quick moving or shifting of inflammable scenery near the innumerable gas lights; the drying up of woodwork on the stage by the heat due to the numerous lights.

As indirect causes of fire, I may lastly mention: An undesirable site, the danger from contiguous or adjacent houses and property, the bad arrangement of the plan, the use of bad materials in construction, defective general system of construction without division into separate fire risks; the misuse of a part of the premises, as living or sleeping apartments, as kitchens for restaurants; or for dangerous trades, or stores; the want of proper fire appliances and of a fire watch; the absence of fire alarm telegraphs, or delays in sending the alarm; frequent changes of watchmen, fire watch and stage hands, and the fact that even men occupying responsible positions grow careless after long time.

The danger of fire in a theater is also, to some extent, dependent upon the character of the play, whether the plain comedy or drama, or the more elaborate opera, ballet or spectacular play; the arrangement and size of the stage, the method of lighting used, incandescent electric lights being without doubt the safest to use, and the age of the building, the first five years being, as found by experience, among the most dangerous.

CAUSES OF PANICS.

Panics may occur in any place of assembly where large crowds of people are congregated, even when there is no outbreak of fire, and sometimes very trifling causes may create terrible panics. It is, in many respects, much more difficult to prevent a panic in a theater than a fire; and, what is worse, panics may become quite as dangerous in fireproof buildings as in those of a combustible nature.

The immediate causes of a panic may be: A sudden outbreak of fire; a false cry of "fire," the false alarm being given either by some excited or frightened, foolish person in the audience, or sometimes intentionally, as, for instance, by pickpockets; a sudden commotion on the stage or in the audience; the sudden appearance of smoke on the stage from burnt fireworks or otherwise; the unannounced darkening of the house; a sudden extra pressure of gas at the footlights, causing the flames to flare up unduly; the sudden extinguishment of the electric light; a fire alarm in the neighborhood, or even only the rattling noise of passing fire engines; the reflection of a fire in the neighborhood of the theater; a thunder storm or stroke of lightning; persons fainting in the theater; horses on the stage becoming frightened and shying, or falling into the orchestra pit, and others.

Features in the construction and arrangement of a theater which may indirectly lead to a panic are: too few exits; various exit passages crossing each other; obstructed aisles or corridors; too narrow stairs; winding stairs; doors opening inward; doors opening in dark corridors, and safety exits kept under lock and key.

The best way to prevent panics is to give to the theatergoers a feeling of security by planning a very ample number of wide exits, so as to enable the quick and quiet emptying of the house, by arranging easy stairs, by providing at least two separate stairs for each of the tiers, by arranging a larger number of stairs for the visitors in the gallery, by installing the electric light in the theater, particularly on the stage, and providing also auxiliary lights in the corridors, stairs and exits. Furthermore, by making it known to the theatergoers that safety appliances are provided in abundance, chief among these being large stage ventilators, a fireproof curtain, fire walls dividing the stage and the auditorium, the fireproof treatment of scenery and of woodwork on the stage, also the putting up and keeping in readiness for instant use in an emergency of plenty of fire extinguishing and life saving appliances, including an automatic sprinkler system on the stage, which must be kept in good working order. Finally, by informing the public that a strict fire watch is kept, that the theater is frequently inspected and by issuing and publishing stringent regulations referring to theater management.

DANGERS TO HUMAN LIFE.

To further understand correctly the subject of theater fire catastrophes, let us consider briefly the various ways in which human life is endangered in a theater fire or panic.

At the outset I will state that it is an error to suppose that the flames are the chief cause of death in theater fire catastrophes. The lessons of all theater calamities point to the fact that it is not the fire, but the smoke, the fire gases and the intense heat incident to the fire, and on the other hand, the mad rush in a panic, which kill most people. Indeed, the majority of people, particularly in the upper galleries, are suffocated or trampled to death before the fire reaches them. In many of the theater conflagrations cited above the bodies of victims were found perfectly intact and either in a sitting position or else fallen upon the floor dead, without the flames ever having reached them.

The lives of people in theaters, whether spectators, actors, musicians, chorus singers, ballet girls or stage hands, are, therefore, endangered:

1. By smoke, fire gases, heat, asphyxia, exhaustion.
2. By fire burns.
3. By jams, knocking over, falling down stairs, trampling, crush.
4. By direct shock or fright.
5. By accidents, such as the falling of the central chandelier.

These various causes may result in (a) almost instantaneous death; (b) mortal injuries; (c) injuries resulting in permanent bodily disablement; (d) temporary illness and recovery.

The long list of theaters destroyed by fires breaking out during a performance, and the numerous instances of fires breaking out during these hours, but which are put out before spreading, are proof sufficient that the dangers spoken of are constantly threatening the theater-going public.

To sum up, chief among the causes to which serious calamities are due are open lights and inflammable scenery; defects in gas lighting and gas piping; defective gas lamps; faulty construction of the building, deficient exits and absence of a fireproof curtain, or where same is provided, curtain not used or out of order, absence of fire extinguishing appliances or lack of water under fire pressure; auxiliary lights in corridors, exits and stairs not provided, absence of smoke ventilator over the stage, accumulation of inflammable scenery, and bad management in the theater.

MANUFACTURE OF METALS OF THE ALKALIES AND ALKALINE EARTHS BY ELECTROLYSIS.

By W. BORCHERS.

IN the construction of apparatus for the manufacture of the alkali metals by the electrolysis of the fused haloid salts of the latter, the following rules must be observed: 1. The alkali metal must be deposited at a metallic (iron) cathode. 2. The cathode space must permit of the collection and removal of the metal without the latter coming into contact with reducible substances. 3. The anode must be of carbon. 4. The anode space must permit of the ready removal of the halogen, and its walls must be constructed of material capable of withstanding the action of halogens and haloid salts. 5. No metallic particles should be present in the melt between the poles. 6. All the parts of the apparatus must be constructed of fire-resisting material.

These conditions are partially fulfilled by Grabau's apparatus (1889), and also by an apparatus described by the author in 1891. The whole of the difficulties have only been surmounted, however, by the construction of the apparatus shown in Figs. 1 and 2. It consists of two communicating vessels, of which one, the cathode space, K, is of iron; the other, the anode space, is of chamotte. A jacket is furnished for the anode, a, by means of which no chlorine can reach the cathode, and the outside of which is out of contact

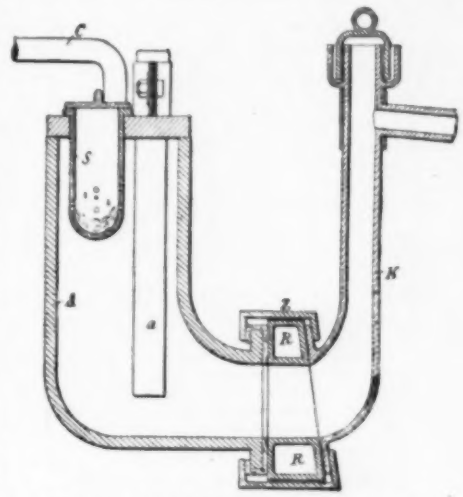


FIG. 1.—COOLING WATER INFLOW.

with the melt and with the strongly reducing alkali metals. The employment of a tubular cathode for the collection and discharge of the metal is also possible, on the inner side only of which the metal can be deposited, as the outer side does not as a rule come into contact with electrolytes. The two vessels are bound together by a hollow metallic band, R, and two clamps, Z, above and below it; a stream of water passed through the hollow band locally solidifies the melt, which effects the luting. The flange between the vessel, A, and the band, R, is packed with asbestos, which acts as a damper in order to prevent cracking. A tube, C, serves to lead off the halogen. Dropping the salt

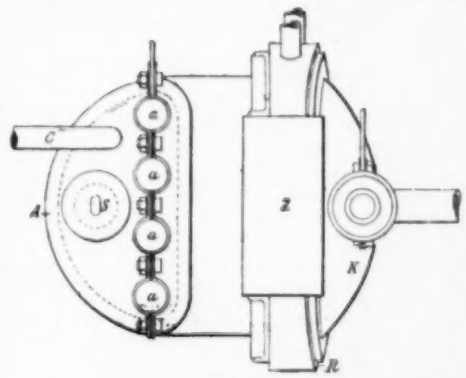


FIG. 2

directly into the anode vessel is apt to cause the latter to crack; the salt is therefore introduced in small lumps through S, the bottom of which is covered with a layer of asbestos.

The current density of the cathode should be about 5,000 amperes per square meter. An advantage of the new apparatus is that with a current density remaining constant at the cathode, the current density at the anode may be reduced, which means a great saving of energy.

The electrolytic preparation of the alkaline earth metals presents many more difficulties than that of the alkali metals. The mixtures of salts melt only at a

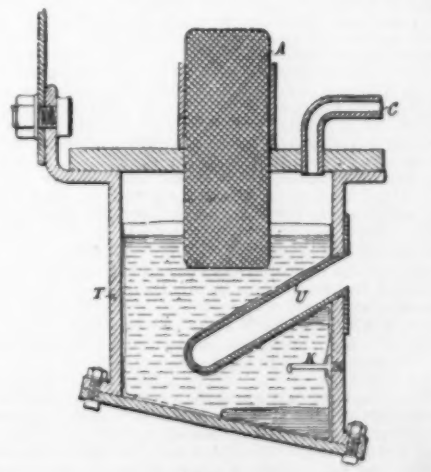


FIG. 3.

red heat, and the metals themselves at still higher temperatures. The melting point of barium, for example, is near to that of iron; then follows strontium, calcium having the lowest melting point of the three.

A current density at the cathode of 1,000,000 amperes per square meter is necessary. Fig. 3 shows an im-

proved apparatus for this purpose. A wrought iron crucible, T, serves for the decomposition vessel; a U-shaped piece of sheet iron is inserted into it at U, and below this pins, K, which serve as cathode, are screwed into the walls of the vessel. The size of the pins is so regulated that during the electrolysis there shall be a current density of one ampere per square mm. of exposed surface. A strong bar of carbon, A, serves for the anode, or a bundle of thin rods or plates of the same material; a tube, C, is furnished to lead off the halogen.

The modus operandi is as follows: The fused haloid salts of the alkaline earth metals are poured into a cold crucible, the heated bar of carbon immediately dipped into the melt, and connected with the current. The walls of the crucible are covered with a crust of the solidified melt, which isolates them completely; this is therefore maintained during the operation by cooling either by air or by water. The crust is only quickly remelted at the cathode. The resistance of the melt must be great enough that the current causes a sufficiently strong heating to keep the electrolyte molten. In consequence of the great current density at the cathode, this is heated far above the surrounding temperature. The metal here deposited may agglomerate to a molten mass, which falls or rises, and finally solidifies under U. The great current density causes much of the metal to be swept into the anode space, where naturally it is oxidized; a portion of the metal, after dropping from the cathode, is also dissolved by the haloid salts, forming basic compounds. The highest yield of metal realized is 20 per cent. of the theoretical; this, however, shows a great advance, for with the arrangements at hand heretofore only a 5 per cent. yield is attainable.—Zeits. f. ang. Chem., 1893.

[Continued from Supplement, No. 981, page 15681.]

PHOTOMETRY.*

By Capt. W. de W. Abney, C.B., F.R.S.

LECTURE III.

The sensitiveness of the eye to changes in intensity, I have shown you, varies according to the intensity of light from which the variation takes place. As my time is short, I must omit some other theoretical considerations which it was my intention to show you. I will first of all commence by showing how it can be ascertained whether a light is up to the standard temperature, such standard temperature being required for visual and photographic comparisons.

It is well known that by mixing two properly chosen spectrum colors white light can be formed, and when I say white light, I mean the color of the light under trial. Now, for lecture purposes, it is useless for me to try and use the light of a candle to form a spectrum. It would be invisible to all; but I can use the electric light just as well for the object I have in view, viz., the demonstration of the principles involved. Now the whiter the light, the more blue and violet there is in its spectrum. There is, therefore, a large quantity of blue and violet in the electric light. I will form a spectrum, and place a slit in the orange and another slit in the blue, so that I can have a slice of each colored light. By means of a lens I can cause these two slices of spectrum colors to expand and overlap and form an image of the face of one of the prisms used, and I can then cause a beam of the original light to illuminate a white surface alongside of it. The two slits can now be opened till they form by their mixture exactly the same color as the original beam. Let us see if we use another source of light whether we shall get exactly the same result, keeping the slits as they are. I tone down the electric light by a very pale yellow glass: the light imitates very closely gas light. If we place it in front of the slit of the spectroscope, so that the spectrum is the spectrum of the yellower light, and the incident beam is the yellow light, you will see at once that the mixture of the two colors no longer gives the same color as the yellow light. Making the light the same as the amylacetate lamp light, you will see again that the balance is upset, the two patches of light on the two white surfaces are no longer the same.

Here, then, we have an indication of the method to pursue in ascertaining if lights are of the same quality. By having two adjustable slits in the spectrum, which will with a standard light exactly match the color of such a standard, we can at once see if any other light is of the same value; if it is not, the two illuminated surfaces will be of a different hue. Another plan is to use proper colored glasses in front of a lens, and allow light to pass through them in such proportions that they cast an image of a beam of exactly the same color as that of the standard light itself. When another light is used, equality of color no longer exists.

There is one method of altering the intensity of a light, if it be a glow lamp, which may interest some. In the first lecture I showed how the visible rays increase in intensity in a parabolic curve. This was further investigated by General Festing and myself. If each ray goes up parabolically, it is probable that the sum of them does the same. In a paper read at the Royal Society on December 8, 1887, we showed that our surmise was correct, and that if a constant was deduced from the current multiplied by the volts, the result was the square root of the light multiplied by a constant—$(w - m = n\sqrt{y}$, which is a parabolic. By altering the resistance in the lamp, and reading an amperemeter, and a voltmeter, the result is obtained, though it is sufficient if the amperes alone be read, for then $c^t - s = t\sqrt{y}$, very nearly when c is current and y the light, s and t being constants.

As to the use of the sectors, it has been brought to my notice that Mr. Ferry has called in question the accuracy of the sectors when comparing lights of different colors with one another, such as lime light and a glow lamp. He states that for light of the same color, and for monochromatic light, no error can be found in its use. I may refer, however, in opposition to this, to some experiments which were carried out by General Festing and myself, in which the luminosity of the spectrum was measured without the intervention of the sectors, comparison having been made with a glow lamp. It was found, as published, that the two methods gave identical results. There are many other experiments which show that no error in the results obtained with the sector have been found by us. That this is the case, we may take to be the fact by direct and by indirect measures.

There is, in my opinion, no method so good in photometry as that of using properly moving rotating sectors, whose open apertures can be altered at will. It allows both lights to remain stationary, as, also, the screen. This method of diminishing the intensity of the light was, I believe, first introduced by Fox Talbot more than fifty years ago, though he had not the advantage of using movable apertures. This principle of altering the aperture during rotation I first saw exhibited by Mr. Kempe, Q.C., at a soiree of the Royal Society. It was applied to a color top. Without entering into the history of the matter, however, let me show you the exactitude with which such sectors can be employed.

In doing this, I wish to introduce to your notice a photometric method which I brought out, and is, I believe, very fairly successful. I am not saying it is the very best for comparing ordinary lights, but it fills

Back View.

Fig. 1.

a gap for measuring light transmitted through bodies, which is very convenient. The principle of the screen, which you will at once see, is different from almost any other. It consists of a square aperture cut in a thin disk, and over this is stretched a white piece of paper of such a nature that the light from an illuminant is only scattered, and no direct image can be seen under any circumstances. On the other side is cut a mark in black paper or black retint, which is exactly double the size of the cut-out square, and this is filled up by the white paper stretched over the aperture, so that we have a rectangle of paper half of which is translucent and the other half opaque. If now we place a light behind the aperture, the half is illuminated by transmitted light, and if a light is placed on the other side, the whole rectangle is illuminated. By placing a rod in the path of this last beam, we may cast a shadow which prevents the last illuminating the half through which the transmitted beam comes, and then we have half the paper rectangle illuminated by transmitted

Front View.

Fig. 2.

light and the other half by incident light. If the paper be of good quality, the light will appear of the same color. By placing the rotating sectors in the path of the front beam, and altering the apertures, we may cause the two to appear of equal brightness.

Now suppose I want to examine the amount of light transmitted through this piece of ground glass, I can readily do it. If I place it near the candle, and use an ordinary Bunsen or Rumford photometer, I shall find that it varies according as I place it close to the source of light, or half way, or close to the screen. It is quite evident that the closer I place it to the screen, the truer will be the measure of the total amount of light transmitted. With this photometer I can get the ground glass close to the screen, and we then get a measure of the transmission of light through it. An objection has been made that light has been reflected back from the surface of the white paper to the glass and back from that surface again. This may be true to a very limited extent. If I take a piece of ordinary glass, and hold it close to the lamp, I can balance the two lights, bringing it closer and closer, till it in fact almost touches the aperture, you will see that the balance is undisturbed. A variety of experiments has shown that any error caused by this is negligible. We can take a piece of a photographic negative, and test it in the same way, and balance it, and move it at different distances toward the screen; we find that if we strike a balance when it is near the light it becomes apparently darker as it approaches the light, then gets lighter and lighter, till it appears lightest of all as it approaches the screen. Another point is this, that it need not be used in a totally dark room, where provision is made that any light there is must pass through the body under measurement; a small amount of diffused light is of no very great moment anywhere, since it illuminates the front of the rectangle, and has no effect on the measures of the light transmitted. We can also use it for colored objects, such as colored glass. For ordinary purposes it suffices if the glass be placed against the aperture, or in the path of the beam somewhere, so long as the aperture is only illuminated by the light transmitted through the glass. This makes one half colored; but it is easy to balance the illuminations by the oscillations of the sector. [This was experimentally demonstrated.] The light passed through is then very easily found. Again I may use colored paper and do the same. To myself it is more easy to balance a colored light against a white one than a white one against the white. I need scarcely say that, first of all, the illuminations of the white surfaces are balanced, and the sector opening read before the light coming through any colored or other body is measured. If the white surface require a sector opening of 80°, and only 40° when a body is against the aperture in the screen, half the light is transmitted.

We may often want to know the amount of light reflected from a body, and the next photometer I shall show you is used by me for that purpose. It is very similar in principle to the last. The aperture is cut as before, but, instead of being covered up, it is left open to allow the colored object to be placed in it, alongside a white square. Instead of two lights, one light may be used for this photometer, a reflection being used instead of the second light. This avoids any alteration in the relative intensities of the two lights used, for they both are from the same source. A rod casts shadows, one on the aperture and the other on the white square. The aperture is fitted with, say, a gray square, and the sectors in the direct beam altered till the two appear of the same color; or I may introduce a colored object and repeat the process. In this case, of course, first of all the aperture should be fitted with a white surface and a measure taken, and the aperture of the two measures of the sectors gives the relative brightness of the two objects.

There are often cases where we may wish to measure bodies which only allow but very little light to pass, though they are transparent. In such a case we have to use a very powerful light, and it may be that the body varies greatly in absorption at different parts. For this reason I use the electric arc light as the source, and concentrate it so as to give a brilliant beam. There are, however, variations in the electric (arc) light from time to time, and unless the comparison light, with which the relative intensities passing through different parts of the wedge are measured, varies at exactly the same time and in the same proportion, the measurements will often be very much out. If we merely wish to measure the white light transmitted, the apparatus to employ is not very extensive, and Fig. 3 will show what it is. E L is the

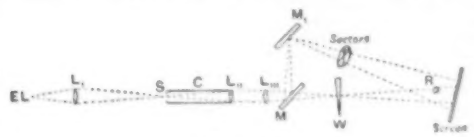


Fig. 3.

electric light, placed in a lantern, or box of some kind, to prevent the room, which should be slightly darkened, from being flooded with light. L_I is a condenser which throws an image of the crater of the positive pole upon the slit, S, of the collimator, C. The rays issue parallel, and are caught by a lens, L_{III}, which forms an image of the slit upon the surface of the wedge, W, placed in a proper position and in its mountings. The light, after passing through the wedge, forms a circle of light on the screen. It will be noticed that the image of the slit may be as narrow as one wishes by opening or closing S, and that we have a line of light passing through the wedge, such as is required to effect the graduation. Calculation will show that, with a fairly narrow slit, the measured intensity passing through it may be taken as that passing through the mean thickness of that part on which the image falls.

Placed in the path of the beam, and between the wedge and L_{III}, is a plain mirror, M (for which I often substitute a prism of 1½°, and so obtain a single reflection), which reflects the light at right angles, or any convenient angle to its path. It is again reflected from M_I, a silver on glass mirror. An image of the slit is formed in the path, and a second disk is formed on the screen. The center of this disk is made to coincide with the center of the disk formed by the light passing through the wedge. A rod, R, is placed in the path of the two beams, which casts two shadows, one illuminated by one beam and one by the other. The usual black mask is used on the screen, to confine the attention to a small part of the shadows.

It will be seen that when any variation takes place in the light it equally affects both the illuminated shadows; hence the measures may be made without fear of error creeping in. Sectors with apertures, moving at will while they are rotating, are introduced, as shown in the figure, and sometimes a second set of fixed sectors are introduced between M and W should the light passing through W be too bright. The screen is placed perpendicular to the line bisecting the angle made by the two beams. It should be noted that this plan almost necessitates movable sectors, but sectors which are fixed at known apertures can be used at a pinch, and the balance made by moving the wedge in its settings.

It should be remarked that though the wedge may not be pure black, the readings can be very readily made by the method of oscillating between "too light" and "too dark" for the shadow whose brightness is controlled by the sector. In making a valua-

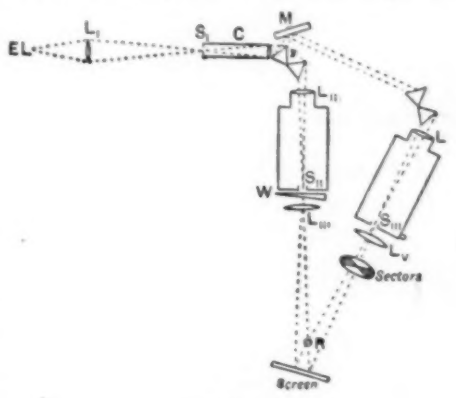


Fig. 4.

tion of the wedge, the first thing to do is to compare the lights without the intervention of the wedge, and then to take readings.

For certain purposes it is necessary to know how much of each color of the spectrum is transmitted through a wedge, and Fig. 4 shows how this is accomplished.

The electric light and the collimator are placed as

* Lectures delivered before the Society of Arts, London, 1894.—From the Journal.

before, but the parallel emergent rays fall upon a pair of prisms, and the spectrum is brought to a focus by L_{111} onto a screen in which there is a slit, against which the wedge in its setting is placed. The slit can be placed in any spectrum ray, and the wedge surface is always kept perpendicular to that ray. A lens, L_{111}, brings the rays to a focus, so that a monochromatic image of the surface of the last prism is formed on the screen. From the surface of the first prism parallel rays are reflected; these are caught by a mirror and fall on a pair of precisely similar prisms, and the remainder of the apparatus is exactly the same as that described above, a second patch of colored light being formed over the first patch. The slit, S_{111}, is so adjusted in the spectrum that the two patches are of the same color. The sectors are placed as shown in the figure, the rod, R, forming two shadows, as before. The method of procedure is to place the slit, S_{11}, in some color in the spectrum and S_{111} in the same. The wedge is then graduated for this beam throughout its length, another position is taken up, and the same process gone through. By this means we get the logarithmic factor of transparency for each part of the wedge for the whole of the spectrum colors.

The last point that I shall have to refer to is an apparent failure of the law of inverse squares as regards photometry.

I have upon the screen two patches of spectrum light—a red and a green—of equal intensity; if anything the red is rather the brighter. I place the rotating sectors in front of them and gradually close them. Notice that the red begins to fade away much more rapidly than the green. When very nearly closed the red has disappeared and the green remains, not of its light green color but as a green gray.

Let us argue from this what should result. If, when we illuminate a screen with red light, we can remove it to such a distance that the screen becomes invisible, though if we have green light, which appeared of equal brightness when close to it, we should be able to remove it much further before the same screen became invisible. The point at which the screen disappeared from view would evidently be the zero point from which the illumination would have to be reckoned for the color which was used. So with white light, there is a point at which the screen would become invisible. Evidently, then, the law of inverse squares for illumination appears to fail for low intenseness of light, and this is owing to the insensitiveness of the eye. Theoretically, of course, the screen may be moved to an infinite distance and still be visible. The law is obeyed practically, of course. It may be thought that this limit of vision is of no practical account. But I must say that it is. For instance, in the photographic room we use red light, and we find that the corners of a fairly sized room are invisible. If we use canary medium, the corners will be well illuminated. This is owing to what I may call the superior space penetrating power of illumination of the yellow-greenish light over the red.

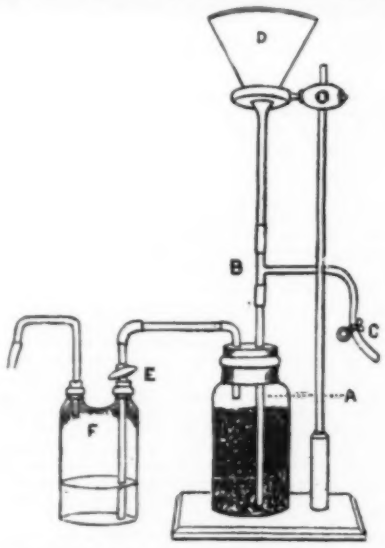
A NEW SULPHURETED HYDROGEN APPARATUS.

By J. F. LIVERSEEGE, F.I.C.

MOST of the arrangements used for preparing sulphureted hydrogen on a small scale suffer from either or both of the following disadvantages: (1) The size of the hole through which the ferrous sulphide is introduced to the generator requires the sulphide to be crushed rather fine, with the result that there is a good deal of powder which gets into the acid bottle and continually generates the gas. (2) The tube between the acid bottle and the generator is small and is frequently stopped up.

To avoid these troubles, some four years ago I devised the following arrangement:

The generator, A, is a pint green glass wide mouth



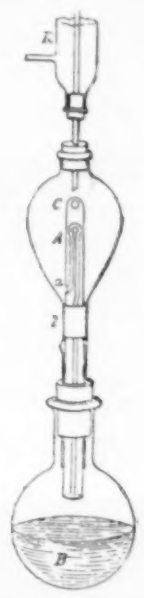
bottle, with broken glass at the bottom an inch deep, and on it the lumps of sulphide; as the neck is $1\frac{3}{4}$ inches in diameter, fair sized pieces can be put in. This is closed gas tight with a cork or rubber bung coated with paraffin wax; through it pass two glass tubes; one, just through the cork, is connected with a pint Woulff's bottle, F, for washing the gas; the other, $\frac{5}{8}$ inch inside diameter, reaches nearly to the bottom of the generator, and is connected by means of a T-piece, B, with a large glass funnel, D. The other leg is closed by a rubber tube and pinchcock, C.

A little water is put in the funnel and commercial hydrochloric acid added. As the gas is generated, the liquid is forced up into the funnel, the layer of glass at the bottom preventing the sulphide soaking in the acid. A glass stopcock, E, is used for regulating the supply of the gas. When no more gas is required, the pinchcock, C, is removed, and the acid runs out through the side tube into a bottle for future use with more acid if necessary.—Chem. News.

A NEW EXTRACTION APPARATUS.

By L. ETAIX.

THE apparatus consists of an adapter (A), and ground so as to fit into this (2) a large tube, the lower end of which is several centimeters below that of the adapter, and the upper end of which opens laterally (C) into the upper part of the adapter. The tube contains within it a smaller tube, curved to form a siphon, its shorter branch communicating with the interior of the adapter, its longer branch descending freely to the



bottom of the large tube. To make use of the apparatus the tube is withdrawn from the adapter, a ring of glass wool introduced at the level of the opening of the siphon (a), and a little glass wool also placed in the lower part of the adapter. The substance to be extracted is put into A, up to the level of the top of the siphon.

For extraction in the cold, arrange the apparatus above some kind of reservoir, and below a dropping funnel, so that the solvent falls in drops on to the substance; the solvent accumulating finally covers the substance; and the level of the liquid being now above the curve of the siphon, the latter completely empties the adapter.

For a hot extraction, arrange the adapter above a flask (B), and connect it with an upright condenser (R). Introduce into the flask a volume of solvent at least equal to the total capacity of the adapter. On boiling the solvent, the vapor liquefies in the condenser, and falls back on to the substance, the further action being as before, with the addition that the vapor in passing upward serves to keep at a boiling temperature the liquid covering the substance.

METHOD OF TESTING FOR ALBUMINURIA.

By PHILIP JAISOHN, M.D., Washington, D. C.

THERE are innumerable methods for testing for albuminuria, but one must select the best process and use it constantly in order to be thoroughly familiar with the method, and derive practical benefit therefrom.

Among the common methods, the one most frequently used by the practitioners is: Boil the urine, then add a few drops of nitric acid to ascertain whether or not the urine is cloudy. But this method is too inaccurate to be of any service; and there is another method known as Heller's test, which consists in adding nitric acid carefully to the urine contained in a test tube, and observing whether or not a band of cloudiness exists at the junction between the urine and the acid. This method is preferable to the former, yet there is a chance of making a mistake; because, if there should be phosphates present in the urine, there will be a cloudy band, which, however, differs from the cloudy band caused by albumen; but it is sometimes very deceptive to the inexperienced eye.

I know another test, which is as follows: First acidulate the urine with acetic acid. (Filter it if turbid.) Fill the test tube one-third to one-half with the reagent composed of the following ingredients: Bichloride of mercury, 8 grains; tartaric acid, 4 grammes; distilled water, 200 c. c.; glycerine, 20 c. c.; and then add the urine, drop by drop. By this method one can detect albumen in the urine, when present in the proportion of 1 to 50,000. This is the most delicate test known; even more delicate than the trichloracetic acid method, which is considered one of the most delicate.

But I have come to the conclusion that these two methods are of no practical use for clinical purposes, because by them one can detect albumen in the majority of cases, whether healthy or unhealthy. This is especially true of the bichloride of mercury test. I have examined twenty specimens of healthy urine and have found albumen in eighteen cases, by the mercurial reagent, which shows the worthlessness of the test. It is a well known fact that even healthy people pass a very small quantity of albumen during certain hours of the day; especially during digestion, and there is no pathological significance in this.

However, if one applies such a delicate test as the one I mentioned, the albumen will show plainly, and will cause unnecessary apprehension to the physician as well as to the patent.

There is one method I am in the habit of using, and which I consider the most reliable and practicable. It is more accurate than the method of boiling the urine and adding a few drops of nitrate acid, and not so delicate as the trichloracetic acid or the mercurial mixture.

Put a few drops of liquor potassii in a test tube full of urine and filter it. Fill the test tube one-half with the filtrate; then add fifteen to eighteen drops of fuming nitric acid. By this time the clear urine will be somewhat cloudy, if it contains albumen. Boil it over an alcohol lamp or Bunsen flame, and let it stand for one half hour. There will be a sediment of whitish flakes or brownish granules. Boil it again and observe whether or not these will dissolve. If it is albumen, they will not dissolve by the second boiling.

This is a fact of especial importance to medical examiners for insurance companies. It is their duty to guard against the admission of undesirable persons to the companies with which they are connected. But, at the same time, they must not apply too delicate a test in examining the applicant's urine; as, by applying such test, the albumen is apt to be found in most cases, resulting in the rejection of the applicant upon the ground that he has albuminuria. Of course such rejections by the medical examiner will be a loss to the company

On the other hand, the medical examiner makes a grave mistake who applies such a crude and inaccurate method as boiling the urine, and adding a few drops of nitric acid, and then declares that there is no albumen; and the applicant is accepted, even though he may have albuminuria. The last-named test will not always bring out the albumen, unless there be a considerable amount in the urine.

Admitting applicants to the companies on the strength of such a test, in my opinion, is running a great risk. The method I prefer and already described, is really the modification of so-called "heat and nitric acid test." If albumen shows by this test, it is a case for clinicians to watch the patient more carefully, and for the examiners of insurance companies to be justified in rejecting the applicant.

I may add here, that examination of urine should be required by the army, navy, and marine hospital service, in connection with physical examination of candidates for soldiers, officers, and sailors.

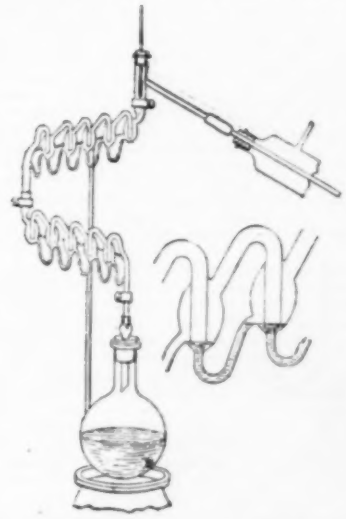
There is no other secretion or excretion in the human body which gives more information about the internal affairs of the constitution than urine, and it is therefore a subject deserving a careful study and investigation. It is hoped that in the near future all the practitioners in the land will realize the importance of this, and examine the urine of their patients whenever it is possible. It is true that most general practitioners have neither time nor facilities to do the chemical and microscopical examination of the discharges of their patients; but it is advisable for them to have this kind of work done by some one who has experience, skill, and time to do it. It is a justice to the patient as well as to the attending physician.—Medical Record.

FRACTIONAL DISTILLATION.

By M. OTTO.

THE apparatus consists of a series of egg-shaped bulbs connected with each other on the top by wide tubes, and by narrow tubes on the bottom, in the manner shown in the diagram.

Experiments with mixtures of benzene and toluene,



and methyl alcohol and acetone, show this apparatus to be vastly superior to fractionating tubes of the well-known Le Bel-Henninger type.

TESTING PYRITES.

AN experimental inquiry has recently been made by Mr. T. S. Gladding into the reliability of the various methods of estimating sulphur in pyrites. He finds the fusion method gives high results, and the bromine method without the removal of iron low results. As the result of his investigations and of many comparative analyses made during a period of many years he recommends the following method of procedure:

1. Grind to an impalpable powder, dry at 100° C., and keep in well-corked bottles. Ten to fifteen minutes' drying is sufficient.

2. Weigh one gramme, introduce into beaker, cover with watch glass, and add ten c. c. bromine solution, mix by rotating beaker and allow to stand ten minutes in the cold. Add ten c. c. nitric acid, mix as before, and allow to stand ten minutes longer in the cold.

Finally place the beaker on a water-bath, containing cold water, heat slowly to boiling, and when solution becomes quiet remove glass after rinsing and evaporate to dryness. Add ten c. c. hydrochloric acid, keeping the beaker covered with a glass, and when violent action ceases, again remove the glass after rinsing, and evaporate to dryness once more. Add one c. c. concentrated hydrochloric acid and fifty c. c. hot water, digest until solution is complete, filter and wash with

hot water. The filtrate, about 100 c. c., is now saturated with a slight excess of ammonia allowed to stand hot for ten minutes. The precipitated ferric hydroxide is filtered and washed five or six times more on the paper with boiling hot water, the filtrate acidulated with hydrochloric acid in slight excess, heated to boiling and fifty c. c. barium chloride solution added, one drop per second, to the boiling liquid. The solution is allowed to stand overnight, filtered, washed, and ignited, the precipitate of ferric hydroxide is also dissolved in dilute hot hydrochloric acid heated to boiling, and ten c. c. barium chloride solution added. It is allowed to stand overnight and the barium sulphate thus obtained added to the main precipitate. One filter paper can be used for the two precipitates.

The bromine solution is prepared by dissolving seventy-five c. c. of potassium bromide in fifty c. c. water, adding fifty c. c. bromine, stirring and adding water to 500 c. c. The bromine will nearly all dissolve. Another form of bromine solution used by some is made by saturating aqua regia with bromine. The first solution is the more certain, however, to oxidize all the ore without separation of any sulphur. The barium chloride is in ten per cent. solution.

SKETCHES IN INDIA.

The Falls of Gairsoppa, on the Sheravutty River, in North Canara, a dependency of the Madras Presidency, but situated near the west coast of Southern India, were described recently. Another of Mr. William Simpson's sketches of the wild and sublime effects of the tremendous cataract is placed before our readers. He informs us that the almost perpendicular descent of the water is 823 feet in this Maharajah fall. We also show, though belonging to a very distant and very dissimilar region of British India, in one of the most elevated valleys of the Himalaya, the river Sutlej, there a raging torrent in a rocky highland glen. It is crossed by a "jhoola," or rope bridge, which is more like the cable with the "breeches buoy" used on our seashore to rescue the lives of sailors after a shipwreck. The passenger takes his seat in a loop of rope made to slide along the stretched cable, and is hauled over by men on the opposite bank of the river.—Illustrated London News.

[From the Los Angeles Herald, September 23, 1894.]

THE BRONZE AGE IN EUROPE.

A paper read before the Southern California Science Association, September 11, 1894, by Wm. H. Knight, President of the Association.

The prehistoric ages, as now defined by ethnologists, comprise three great divisions, called, respectively, the Stone Age, the Bronze Age and the Iron Age. The first division embraces the period extending back to the oldest discovered evidences of man's existence and reaches down to the time when the first implements made of metal came into use. Only stone, flint, bone and wooden utensils are found in the geologic deposits of the Stone Age. In the succeeding or Bronze Age, knives, axes, spears, swords and other objects in great variety, made of an alloy of copper and tin, were extensively used, but iron was unknown. The epoch immediately preceding historic times is known as the Iron Age, because the metal from which it derives its name then came into general use.

The Stone Age dawned upon Western and Central Europe at a period so remote as to be clearly identified with a geological era preceding the present. The two great divisions of that age, paleolithic and neolithic, were of vast duration, yet the progress of the human race in useful arts and modes of life was slow and inconsiderable, to be measured only by comparisons made thousands of years apart.

The bronze epoch, on the other hand, brings us down to almost historic times, and is characterized by a rapid development of the race in the mechanic arts, husbandry and an organized and complex social life.

The imagination, groping backward into the dim recesses of the remote past, is enabled, through the researches of archæologists, to picture a time, perhaps 50,000, possibly 200,000 years distant, when a lithe, agile, erect form roamed the primeval forests of the pregiacial period, eluding the mammoth, rhinoceros, giant tiger, lion and other fierce beasts in his quest of the nuts, berries and roots which served him for food; and disputing with the bear, the wolf and the hyena the shelter of thickets, caves and overhanging rocks; for these were his fireless habitations.

When this strange being first gave shape to the bough of a tree, and used the club so formed as a weapon of defense against other wild animals; when he selected a pointed flint or flattened bowlder, and by grinding it on another stone fashioned it into the semblance of a knife, or ax, and thus created an implement that enabled him to achieve more than his fellows, he exhibited mental acumen and manual skill that entitled him to a place in the ranks of man. When again, after the slow lapse of many ages, he had sufficiently developed his thinking, inventive and creative faculties, to dig from mineral deposits, smelt and mould a metallic ore, converting it into a domestic utensil, an agricultural implement, a decorative ornament, or a weapon of warfare, he had made an advance in material progress which was of the utmost importance in the intellectual development of the human race.

The process of shaping a flint arrowhead, or grinding a stone hatchet, each individual making his own tools, was an infinitely tedious one, tending to keep the mind constantly narrowed down to its plodding work. The forging or moulding of a bronze knife or battle ax, on the other hand, while productive of more effective, varied and durable implements, also resulted in enormous time saving and labor saving—one skilled artisan doing the work for many individuals. This afforded leisure for observation, investigation and experiment, and the latent energies were diverted into new channels of industry and new fields of adventure. Indeed, the gain to material progress arising from the use of bronze over stone implements may be compared to the quickened intellectual progress which followed the substitution of movable types for written characters at the close of the middle ages.

The art of bronze making was perhaps discovered by some keen-witted individual belonging to an advanced Stone Age tribe, from whom a knowledge of the art spread to contemporaneous tribes and nations. If this hypothesis be true, the interesting question confronts us, "When and where did the art originate?" As yet it is unanswered, and we can only speculate, using the dim and flickering light afforded by the meager relics which, in the past few years, have been exhumed from an oblivion of ages, to guide our researches and illuminate our judgment.

First, by what strange inversion of nature did the Bronze Age, deriving its name from a valuable metallic alloy, precede the iron age, representing the most abundant and universally distributed of metals? The answer is readily suggested to the evolutionist. Copper, the principal element in bronze, is frequently found in a native metallic state, it is fusible at a much lower temperature than iron, and is more tractable in hands provided only with rude tools.

Bronze is an alloy of copper and tin, about nine parts of the former to one of the latter, and is not to be confounded with brass, which is an alloy of copper and zinc. Brass is of modern date, zinc being unknown to the ancients.

Copper is a metal of very general distribution. It is found in almost every country of the globe, sometimes in a pure or native state, in which condition it can be hammered or moulded into any desired shape, but far more frequently it exists as an ore, which requires smelting and reduction before it can serve the uses of man. Tin, on the other hand, is a very scarce metal, and never occurs native, but always as ore. There were three principal sources of tin in ancient times in the old world, to wit: the Malay Peninsula and adjacent islands of the East Indies; the Spanish, or what was known as the Iberian Peninsula; and Great Britain, called by very ancient historians the Tin Islands. The Phenician merchants, according to Strabo, sent their ships to Iberia and even to Britain for tin 1200 years B. C.

Though it is not generally distributed like copper, the few mines in which it is found are almost inexhaustible. To detect the existence of this metal in the ore, then disengage it, and finally, after blending it with copper in the right proportions, to cast it in a mould, bespeak much sagacity and skill. For this reason, though copper relics are comparatively rare in Europe, it seems probable that a brief copper age preceded that of bronze. We know that copper utensils were extensively used by the mound builders of the Ohio and Mississippi valleys, who are believed to have flourished many thousands of years ago, and that ancient shafts and mining tools have been discovered in the rich deposits of native copper in upper Michigan. When Columbus discovered America bronze was in general use in the partially civilized countries of Mexico and Peru. On the other hand, there is no trace of manufactured iron in America previous to that event.

To indulge again in conjecture; perhaps some acute Stone Age man, wandering along the upper Euphrates, that cradle of ancient civilization, discovered a mine of native copper, and, curiously handling a nugget, discerned that, unlike stone, it was malleable and at the same time had sufficient firmness of texture to retain a hammer face or a cutting edge under use. These enormous advantages of copper over stone could not long remain fruitless, and soon led to experiments which resulted in its fusion for the purpose of moulding, and then to the admixture of an alloy with it to give it greater hardness. Tin is one of the most fusible of metals, melting at 442° F., and therefore was most likely to be first associated with it.

It is a noteworthy fact that one of the oldest and most productive of tin mines in Cornwall, England, is interlaced with veins of copper, so rich in places that the mine has been alternately worked for copper and tin. How probable, then, that an accidental or experimental union of the two metals should have been made at a very early stage of copper mining in that locality.

We cannot assign a definite period to the Bronze Age, nor determine within a range of many centuries the time when bronze utensils began to displace those of stone. More abundant data, partly of a historical character, enable us to offer a conjectural estimate of the period of transition from bronze to iron. Neither transition was contemporaneous over the habitable globe. Rather such changes were slow and gradual, and we have reason to believe that western Asia, Egypt, and southern Europe, countries bordering on the eastern shores of the Mediterranean Sea, had advanced through the Bronze and Iron Ages to the use of written characters, while portions of central Europe were groping in the Stone and Bronze Ages.

Hesiod (supposed to have written about 900 B. C., the earliest European author whose works have come down to us) states that iron was discovered later than copper and tin; and, speaking of those who were ancient in his day, he said they used bronze, and not iron. Reputable authorities place the epoch of bronze in Europe somewhere from 1,000 to 4,000 years before the Christian era. Other writers, equally plausible, push the beginning of the Bronze Age still farther into the remote past and contend that 7,000 to 8,000 years have elapsed since the first introduction of bronze into central Europe. That the Phenicians of western Asia and their colonies along both shores of the Mediterranean were acquainted with the nature of bronze long anterior to its use north of the Alps there can be little doubt, nor can there be much question that the art of bronze making was introduced into Europe and did not originate there.

The bronze objects, strictly referable to the Bronze Age, which have been brought to light within the last forty years, and which have been labeled and catalogued in the museums of Europe, are very numerous—upward of 40,000 in number. They embrace a wide range of articles, including knives, axes, chisels, hammers, saws, fish hooks, sickles, arrows, rings, lances, swords, bracelets, hairpins, buttons, combs, etc.

It is remarkable that no coins, inscriptions or hieroglyphics have been traced to the Bronze Age. The potter's wheel was unknown, but the art of pottery advanced from the simply useful to the ornamental, the ceramic craze having reached its first æsthetic stage. While we find circles, spirals and geometrical figures painted on earthenware and engraved on some of the bronze objects, there are no representations of plants or animals, a characteristic of the succeeding or Iron Age.

FALLS OF GAIRSOPPA, WESTERN INDIA—BRINK OF "THE MAHARAJAH."

The remarkable race who inhabited the lake dwellings of Switzerland have left behind them many evidences of their peculiar civilization during this epoch. No less than 68 of their villages, containing an aggregate population estimated at 43,000, are assigned to this age, there being no iron implements associated with the bronze relics, while among the debris of other ancient lake villages the iron relics were plentiful and even predominated in numbers. These villages were built on piles driven into the shallow water, near the margin of the lake. The piles were covered with a platform, on which the primitive thatched cottages were erected in groups and approached from the shore by portable bridges. Some of the villages were repeatedly burned to the water's edge, the ashes and cinders serving to preserve partially consumed articles of food and clothing, of great importance in estimating their place in the scale of civilization.

The relics dredged up from the debris of these villages supply the materials for a vivid picture of the gradual progress made by men through successive generations in the Stone and Bronze Ages. As Cuvier was able to restore an extinct animal by examining one of its bones, or as Agassiz, being handed a fish scale, proceeded to correctly delineate the fish to which it belonged and which he had never seen; so the archæologist, studying these meager relics, endeavors to reorganize prehistoric society and endow it with those attributes which would govern human nature when manifested under the limitations of the Bronze Age.

The diffusion of bronze implements, at first occurring only in imperfect productions, caused a rapid development of civilization, as implied by the rudeness of the earlier tools, mere repetitions of those of the Stone Age, contrasted with the more skillfully wrought weapons of a later stage of the same period. The conditions of life became favorable, the dwellings were better constructed and industry made greater advances. The working of leather and the art of weaving were much benefited by implements of metal.

The man of this epoch was round-headed, small, energetic and muscular. His food consisted of wild animals and such domesticated animals as the ox,

sheep and goat, varied with bread made of cracked wheat and barley. He ate berries and fruits, including the apple, which he improved by cultivation, the plum and the pear. The horse and dog were domesticated, probably for the chase, but used for food in emergency. While the skins of animals continued to be worn to some extent for clothing, textile fabrics came into use, particularly those made of wool, and others woven from fibrous plants.

That the family existed is inferred from the fact that houses were built suited to the occupation of families, and from the fact that the oldest traditions of historic times and the lowest savage tribes known at the present day alike recognize the family relation. The grouping of houses into villages implies municipal organization and law, however crude, and a cluster of such villages located on the margin of the same lake or along the same valley would evolve a system of mutual protection under a common executive—the germ of the future state.

Trade and barter must have thrived to some extent, leading to the exchange of commodities and the growth of distinct branches of business. The remains of rude water craft show that boats plied on the lakes and rivers, facilitating intercourse between neighboring towns. But as no traces of wheeled vehicles or even sledges have been discovered, we may presume that animals were not thought of for draught purposes and that roads were unknown. The only highway was the blazoned path of the horseman adventurous enough to visit distant lands for gain or to satisfy an incipient thirst for knowledge. What courage was required to traverse those dark wildernesses, infested by hostile tribes, terrible beasts, or more frightful still, the phantoms of ignorant superstition! Under such adverse conditions foreign commerce could scarcely exist; yet some trade with foreign countries was implied in procuring the raw materials for their bronze manufactures.

The abundance and variety of warlike implements, as compared with those of a utilitarian character, attest the warlike propensities of those ancient races. Doubtless predatory bands from less primitive countries made incursions among the peaceful tribes, in some cases despoiling them and passing on, in other cases settling down among them, diffusing their scanty knowledge, and by mixing the races, increasing their physical and mental vigor.

Having no letters and consequently no literature, the interchange of ideas being exclusively oral, we may assume that the mentality of that age was in a low stage of development, being exercised mainly in providing for material wants. Perhaps the intellect at times was sluggishly moved by the awful phenomena of storms and other strange manifestations of nature. It may, indeed, have been stirred by the recital of heroic acts and personal adventure, which recital, repeated and exaggerated, ultimately settled into traditional lore, and gave form to legends corresponding to those of the Norse mythology. It is even possible that a rude sort of eloquence and poesy existed, for who shall say there were no orators before Pericles nor singers before Homer?

Lastly, we come to the moral aspect of this human and social being, evolved from the toolless and solitary wanderer introduced at the beginning of this paper. At what point in his upward career did conscience begin to assert its sway? When did the first glimmering sense of right and wrong lead him to sacrifice his individual passions and inclinations for the comfort and security of an unorganized society?

The question suggests its own answer. Solitary man has no use for a conscience. There is no one to whom he owes a duty. Social man requires a conscience to regulate his conduct toward his fellow, and as, rising higher in the scale of being, his relations with society become more delicate and complex, keener perceptions quicken and enlighten his sense of duty and increase the binding force of his moral obligations. Reasoning, then, a priori, we must conclude that a people living under the physical conditions of the Lake Dwellers and their contemporaries as far north as the Baltic, possessed a moral sense considerably developed, possibly ready to take on a religious phase, and to ultimately expand under the Iron Age into spiritual capabilities.

Such is an imperfect and desultory sketch of some of the salient features of that picturesque era in the history of man which we denominate the Age of Bronze.

GEOLOGIES AND DELUGES.*

By Prof. SOLLAS, F.R.S.

IN the days when geology was young, now some two hundred years ago, it found a careful foster mother in theology, who watched over its early growth with anxious solicitude, and stored its receptive mind with the most beautiful stories, which the young science never tired of transforming into curious fancies of its own, which it usually styled "theories of the earth."

Of these one of the most famous in its day and generation was that of Thomas Burnett, published in 1684, in a work of great learning and eloquence. Samuel Pepys, of diary fame, is said to have found great delight in it, and it is still possible to turn to it with interest when jaded with the more romantic fiction of our own day.

It was the fashion to commence these theories with chaos, and chaos, according to Burnett, was a disorderly mixture of particles of earth, air, and water, floating in space; it was without form, yet not without a center, a center indeed of gravity, toward which the scattered particles began to fall, but the grosser, on account of "their more lumpish nature," fell more quickly than the rest, and reaching the center first, accumulated about it in a growing heap, a heap, as we might now express it, of fallen meteorites; the lighter particles, which form fluids, followed the heavier in their descent, and collected around the solid kernel to form a deep ocean. This was at first a kind of emulsion, like milk, formed of oily and watery particles commingled, and just as in the case of milk, there separated, on standing, a thick creamy upper layer, which floated on the "skim milk" below. That this really happened, the good Burnett bravely remarks, "we cannot doubt." The finest dust of chaos was the last to fall, and it did not descend till the cream had risen; with which it mingled to form, under the heat of the sun, the earth's first crust, an excellent but fragile pastry, consisting of fine earth mixed with a benign juice, which formed a fertile nidus for the origin of living things. Outside nothing now was left, but the lightest and most active particles of all, and these "flying ever on the wing, play in the open spaces," about the earth, and constitute the atmosphere of air.

Such was the earth when first it formed the abode of unfallen man—perfect in form and beauty, for it was a true sphere, smooth as an egg; undisfigured by mountains, and unwasted by the sea. It was unfortunately but too like an egg, since its fragile shell rested on the treacherous waters of the interior abyss, "the waters under the earth," and the sun over-roasting, finally cracked and burst it; the broken fragments of the ruined world fell downward into the abyss, and the subterranean waters rushed out in a mighty flood to remain as our present seas and oceans, from which the broken crust protrudes as continents and islands. As might naturally be anticipated, the bursting out of the abyss corresponds to the Noachian deluge, which we thus perceive to have been profounder in its origin and wider reaching in its effects than we might previously have supposed. This, for distinction, we may call Burnett's deluge; of his geology we may say that it is cosmological, since it endeavors to trace the history of the earth backward to its origin in chaos; that it is catastrophic, because it attempts to account for all the great features of the earth by a single event which occurred suddenly and with violence; and that it is theologic, since it owes its inspiration to Holy Writ.

As geology grew older it went to school: what was the name of the school is not quite certain; some have called it "Science falsely so called," others, more briefly, "Inductive Science." However this may be, the immediate effect on the manners of young geology was very distressing. It grew contradictory, and was frank in the expression of obnoxious opinions. One of its most irritating remarks was that the world was not made in a week, and it would appear that at this time the relations of child and foster parent became not a little strained. Still geology proved an apt scholar, and its progress was rapid. One of the most important lessons it learnt was that if we want to know how the world was made, the first essential is to study the earth itself, to investigate with patient drudgery every detail that it presents, and particularly the structures that can be seen in river banks, sea cliffs, quarries, pits and mines. Thus it discovered that the solid land beneath our feet is to a large extent composed of layers of sediment which were once deposited more or less quietly at the bottom of ancient seas, and certain curious bodies known as fossils, it concluded to be the remains of plants and animals, sea shells and the like, which were once the living denizens of these seas.

It discovered that these deposits lie so regularly one upon another that it compared them to a pile of books, or to a slanting row of books lying over to cover; and that in some cases, at least, the simile was not strained, will appear if we trace the structure of England from Oxford westward toward Bristol. We then find that the thick bed of clay upon which Oxford stands lies evenly on a series of gently sloping beds known as the lower oolites; these in like manner repose on those thin seams of limestone and clay called the lias, and these in their turn upon the red beds of the trias. It might perhaps have been expected that this uniform arrangement would continue through the whole thickness of the stratified rocks, but it was discovered, and the importance of the discovery was recognized so early as 1670 by Bishop Steno, a man of great genius, that the regularity of the succession is liable to interruption at intervals. Thus as we approach Bristol, we encounter those beds of limestone which are associated with our coal-bearing strata, and which are consequently called "carboniferous;" but these are by no means related to the beds we have just passed over in the same manner as they are to one another—we do not find the highest bed of the carboniferous series offering its upper surface as a gently sloping platform on which the trias may rest; on the contrary, the carboniferous beds are seen to lie in great rolling folds, with the tops of the rising folds absent, as it were sliced off, and it is on the edges not on the surface of these beds that the red trias layers are seen to be spread out. This sudden change in disposition may well be called a break in the succession of the rocks, and, as if to emphasize it and compel attention to it, we find it accompanied by a complete change in the character of the fossils, those occurring in the carboniferous rocks being of entirely different kinds to those which are found in the overlying beds.

Evidently the carboniferous beds could not have been laid down in the sea in the steeply folded form they now present. At first they must have been spread out in nearly horizontal layers, and the folded form must have been subsequently impressed upon them, no doubt by the action of some stupendously powerful force. Subsequent also must have been the removal of the upper parts of the folds and the general planing down which they appear to have undergone.

To the young geology all this might seem perfectly clear, but in its impulsive explanations it assumed that nature must have frequently acted in a great and terrible hurry; thus the folding of the rocks was supposed to have been produced suddenly and violently by a single mighty convulsion, which simultaneously changed sea floors into mountain chains, split open the land in wide gaping chasms—our present river valleys—and with the same blow destroyed every living inhabitant in the world.

But the discordance between two sets of rocks is met with not once only, but several times, in the stratified rocks of the earth's crust, and for every discordance there must have occurred a corresponding catastrophe.

These catastrophes were as wonderful as Burnett's, and there were more of them, so that at this stage of its existence geology was appropriately designated "catastrophic." It had completely severed the apron strings, and ceased to be theologic, but it still to its credit remained cosmologic. It traced the earth from chaos up to a stage when islands and continents rose out of a primeval ocean, the waters of which were boiling; saw it peopled with strange and various forms of life, and watched it run its course, rejoicing in the sun, "chearfull, fresh, and full of joyaunce glad," then pictured it overtaken with disasters, shaken with earthquakes, overwhelmed by floods, and agonizing in the labors of a new birth. Calm followed after storm, and life rejoiced afresh in a remade world to be again destroyed. Thus, through alternations of peace and strife, the earth moved on its changeful way, to the crowning creation of man, who was himself a living witness of the last great catastrophe of all, the Noachian deluge. Its waters covered the whole earth, to the tops of the highest mountains under heaven, and on their retreat they left behind, as a standing witness to their extension, great sheets of sediment, supposed to be spread out over the entire surface of the globe, and appropriately named the "diluvium." The diluvium may be seen in most parts of the British Isles, except in the south of England; it consists of clays and sands, containing vast numbers of curiously scratched stones.

As the powers of geology matured it became increasingly able to dispense with catastrophes. The very diluvium itself was shown to be local in its distribution, and glacial in its origin; masses of moving ice, like that which buries the greater part of Greenland out of sight, covered a large part of the temperate regions, and this it was that produced the curious scratched stones and the deposits containing them, which are consequently no longer called "diluvial" but "glacial." More important yet, land could be shown to be still actually rising from the sea, and mountains growing into the air, but so slowly that the fact was not established without much dispute, which is hardly yet over. Valleys could be shown to result, not from any bodily fracturing of the land, but from the slow wearing action of the rivers which flow through them, and the waves of the sea were shown to be capable of cutting down cliffs and of reducing the land to a plain.

From these facts the discordance in the succession of stratified rocks found an easy solution. Recurring to the instance of the carboniferous rocks and their relations to the trias, we no longer need suppose that the stupendous force which folded the carboniferous rocks and raised them into the air acted suddenly or even very rapidly; judging from the rate at which mountains rise now, their upheaval may have proceeded

BRIDGE OF ROPES OVER THE SUTLEJ IN THE HIMALAYAS.

* British Association address to workingmen.

slowly; a few feet in a century would suffice. If we allow but one foot in a century, it would only require two millions of years to produce a mountain range 20,000 feet in height. The movement might naturally be expected to be accompanied by earthquakes, but there is nothing to lead us to suppose that these would be on a much grander scale than those of the present. During its slow elevation, the mountain range would be exposed to wind and weather, rain and rivers would carve it out into ridges and valleys, and frost would splinter its peaks into spires and pinnacles. Subsequently it would sink beneath the sea, and the waves of the sea, as they battered down its cliffs, would remove the last remnants which had escaped the rain and rivers, and roll over an unbroken plain. On this plain, as it continued slowly to subside beneath the sea, the immense deposits of the trias, lias, lower oolites, and Oxford clay would be piled up.

If the rise of the sea floor into the Bristol Alps took place slowly, and involved a great lapse of time, so equally did the sinking of the land to form the sea floor afresh, and in this long interval time was afforded for great changes in the organic world; and thus we reach an explanation of the great and striking differences which distinguish the fossils of the carboniferous rocks from those of later date.

There is no insuperable difficulty in this explanation; its great merit lies in its accordance with the course of nature as we observe it at the present day; and henceforward it became the motto of geology that the processes of the present furnish the key to the interpretation of the past. The changes in which the life of the earth is manifest are not only slow and gradual now, but they have ever been the same. The earthquakes, which in ancient times shook the land, were no more violent than those of which we have lately read in the daily newspapers; the ancient volcanoes were not more terrible in their outbursts than Krakatoa; floods were not more appalling than those which still from time to time sweep away tens or even hundreds of thousands of human beings from the Ganges Plain, and the earth, instead of falling into convulsions every now and then, proceeds on the even tenor of her way, without haste and without rest, preserving a uniformity in her progress which impresses us with its solemn grandeur, but which sometimes seems a trifle monotonous. From its belief that an unbroken uniformity in the operations of nature extends from the present into the most remote past, geology now came to be called "uniformitarian." It was no longer theologic, no longer catastrophic, and, I am sorry to add, no longer cosmologic. It persistently refused to inquire into the early history of our planet, and restricting its study to the accessible parts of the earth's crust, it abdicated its regal position as the science of the earth, and became, as it were, a mere petty chieftain, dealing only with rocks and the fossils they contain; the fossils, by the way, not rightly belonging to its province at all. And it was because it passed from being a science of the earth to become a mere study of rocks and fossils, that Hutton was able to make his famous declaration that as a result of his inquiries into the system of nature he could discover "no vestige of a beginning, no prospect of an end." Apart from this, however, and in its self-limited career, geology pursued a luminous advance, and as it did so the Noachian deluge began to sink into an oblivion which it might be thought to have scarcely merited. For if the biblical account is to be taken literally, it furnishes us with a catastrophe of the first order, and since it is said to have occurred comparatively recently, or at least in historic time, the uniformitarian, by his own principles, would have been compelled to infer, as the catastrophist had done, that such deluges form a part of the orderly scheme of the world. The universality of the deluge had, however, for various reasons, been denied, not only by geologists, but by writers of other schools of thought, and toward the middle of the century, belief in it among the learned was gradually expiring; such a number and variety of convincing arguments as converged against it could indeed but lead to that result; and that the deluge, so far from being universal, was a local and very local phenomenon, became an article of belief, so settled among all good geologists—and I think I may add theologists—that it may be said to have finally fallen into the deep slumber of a decided opinion, from which I for one have no desire to arouse it.

Thus the deluge, so far from shaking the uniformitarian position, was rather itself submerged by uniformitarian views, and growing geology was in danger of taking the uniformitarian formula for an infallible dogma. It was saved from this by physics, a clever brother of its own, which had now discovered the famous principle of the "conservation of energy," and another equally famous, "the dissipation of energy." From these it was deducible that the duration of the earth as a living planet must be strictly limited in time. It must have had a beginning, and at the beginning was furnished with a store of energy, which it has ever since been spending. In this spending of energy its life consists, and when the store is at length exhausted its life will cease, and it will become numbered among the dead planets.

A good deal of this uniformitarian geology might perhaps itself have guessed, had it extended its views beyond rocks and fossils to the stars and other shining bodies which people the vast realms of space. The present then, strange to say, will still afford a key to the past. We have but to turn to the sun, our nearest luminary, though still more than ninety millions of miles away from us, and in that great orb we find much to suggest the state of our planet some ninety millions of years ago or more. It is scarcely necessary to remind you of the fact that the sun is a body so hot that the most refractory substances known to us on the earth exist in it in a state of gas or vapor; tongues of glowing gas shoot from it like flames; the clouds which emit its brilliant light are probably clouds of carbon or silicon, which have momentarily condensed from a gaseous state; and rain, if rain ever occurs, must be a rain of molten metals, such as iron, which will be dissipated in gas before it has fallen very far.

If we proceed to the more remote nebulæ, largely composed of glowing masses of gas, we find a suggestion of a stage more embryonic still, when the earth had as yet no separate existence, but formed, with its sister planets and the sun, a single shining cloud. On the other hand, if we turn our gaze on our nearest relative—offspring possibly—that dead planet, the moon, we may read in its pallid disk the sad reminder, "Such as I am, you, too, some day will be."

But this was not all that was contained in the admonition of physics; it showed not only that the earth is mortal, but that its span of life, as measured in years, or millions of years, is brief compared to the almost unlimited periods which geology had been in the habit of postulating. If catastrophic geology had at times pushed nature to almost indecent extremes of haste, uniformitarian geology, on the other hand, had erred in the opposite direction, and pictured nature when she was "young and wantoned in her prime," as moving with the tame sedateness of advanced middle age. It became necessary, therefore, as Dr. Haughton expresses it, to "hurry up the phenomena."

With its uniformitarianism thus moderated, geology has again become cosmologic, and neglecting no study that can throw light on any question connected with our planet, has regained its position as the science of the earth: it is henceforth known as evolutional geology.

The change has not taken place without occasional relapses into catastrophism. Some indications of this can, I fancy, be perceived in the writings of that eminently great geologist Suess, who, among other suggestions savoring of heresy, has lately recalled attention to the "deluge," and endeavored to show that though certainly local, and indeed confined to the Mesopotamian valley, it was on a grander scale than we had been accustomed to suppose, or, in plain language, a genuine historic catastrophe.

A local flood must have had a locality, and the clew to this is furnished by Genesis itself, which informs us that Abraham, the founder of the Hebrew race, left his ancestral city, "Ur of the Chaldees," at a time long subsequent to the flood; it is, therefore, rather in the land of the Chaldees than in Palestine that we should be led to seek the scene of this momentous tragedy.

This land is no other than the famous and once beautiful valley of Mesopotamia, through which the great Euphrates and arrow-swift Tigris flow to empty themselves into the Persian Gulf. Almost lost sight of for awhile, interest in it was reawakened some seventy years ago by the investigations commenced by Mr. Rich, and followed up with such wonderful results by Botta, Place, Layard, George Smith, and others. Their discoveries have revealed to us in unexpected fullness the details of a complex and advanced civilization almost, if not quite, as ancient as the Egyptian, and far more profoundly interesting, for the ancient nations of Mesopotamia are the intellectual forefathers of the modern world. The learning of the Chaldees was the heritage of the Jews and Greeks, from these the torch was handed on to the Romans, and Jew and Greek and Roman inspired, and still inspire, for good and evil, the civilization of the nineteenth century. There is much more of the Chaldean in every one of us than we are given to imagine.

The people whom we find in possession at the dawn of history were Semites, the parent stock from which the Jews subsequently branched off; and one has but to glance at their faces and forms, as portrayed in their statues and pictures, to recognize the strong family likeness, while the emphasis with which muscular development is expressed in parts of the human figure suggests that the remarkable assertion. "The pride of a young man is in his legs," was a Semitic opinion long before the time of Solomon.

Just as Egypt is the gift of the Nile, so is Mesopotamia equally the gift of the Tigris and Euphrates, for it is built up of the mud brought down from the mountains by these two streams into the Persian Gulf, which is thus in process of obliteration. So long as the two great rivers were not regulated, they produced terrible floods in the wet season; and one of the earliest works of the Chaldeans was to control their flow by great dams, and by diverting a part of their water into canals. These canals covered the country like a network, and served not merely to ease the rivers, but also to irrigate the land, which thus richly supplied by water, became, under the hot sun so fat and fruitful, that corn is said to have borne 300-fold. Groves of palms, orchards, with grapes and many other luscious fruits, were cultivated, while the pastures supported abundant flocks and herds. It was a true garden of Eden, and differed chiefly from the biblical paradise, which Delitsch thinks was actually situated within this garden, in the fact that even here man had still to earn his bread in the sweat of his brow. This the Turks, who now possess the country, have no inclination to do, and consequently it is rapidly returning to its primitive desolation. Were England as enterprising as she was in the time of Elizabeth, we should rent this land from the Porte, run a railway through it, and thus shorten our route to India by a thousand miles, farm it, and thus provide ourselves with one of the richest granaries in the world.

In a land so favored, it is nothing wonderful that the inhabitants teemed in millions, villages were everywhere dotted about, and in their midst great and flourishing cities arose—Ur, the City of the Moon-good; Erech, the City of Books; Nippur, and, most famous of all, proud Babylon, "The Gate of God," which stood on the left bank of the Euphrates, some 280 miles above its present mouth. In early times, probably about 2300 B. C., the Jews left this beautiful land for some unknown reason, and after various vicissitudes settled in Palestine. Another branch of the Chaldean stock migrated in later times to the northern part of the Tigris valley, where they built many mighty cities, and founded the warlike kingdom of Assyria. Of their cities it is sufficient to mention Assur, which gave its name to the kingdom, and Nineveh, which afterward became the capital.

The Mesopotamian plain, owing to the way in which it has been produced, is an almost dead flat, and offers no natural elevations for building: the Chaldees, therefore, to raise the foundations of their palaces, temples, and houses above the reach of floods and fever, and for better defense against their enemies, constructed, with incredible labor, great mounds, by piling together quantities of sun-dried bricks and rubbish, and building round this a thick wall of burnt bricks, well cemented together. Some of these mounds, as that of Kojundjik at Nineveh, are as much as sixty feet in height, and it has been computed that this mound alone would have required the labor of 20,000 men for six years in its construction. But there was never any difficulty in obtaining all the labor that was wanted. Prisoners of war were compelled to work under the stick, and the building of mounds was one of the wholesome occupations to which the Jews were set during their captivity in Assyria.

(To be continued.)

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